THE EXTRA-STRENGTH SEWER SURCHARGE TO REGULATE INDUSTRIAL SANITARY SEWER USERS

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For:

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ABSTRACT

The extra-strength sewer surcharge (ESSS) is a charge levied against industrial users of sanitary sewers by municipal sewerage authorities as a result of the excessive strength of their wastewater discharge. This study investigates the ESSS as one of the potential mechanisms that could be promoted to control industrial sanitary discharges under the Ontario Ministry of the Environments' Municipal - Industrial Strategy for Abatement (MISA) initiative.

The study methodology includes a thorough literature review, a major national survey of municipalities in Canada, interviews with municipal staff involved in ESSS programs in Ontario and economic analyses of surcharge rates, municipal treatment costs and industrial pretreatment costs. Survey and interview data were compiled and, together with literature findings and economic analyses, were used to evaluate the advantages and disadvantages of ESSS programs. This evaluation focuses on treatment cost allocation effects, inducements for industrial pre-treatment, municipal revenue impacts, impacts on municipal treatment facilities, and administrative implications. Recommendations are provided regarding implementation of ESSS programs. Appendices document the literature review and provide technical detail from study tasks.

Principal study findings are:

. ESSS programs can be an effective component of regulatory programs to control the strength of industrial discharges to sanitary sewers.

. An ESSS charge can be an effective means of equitably recovering the costs of treating high strength wastes.

. Larger municipalities with significant industrial loadings to their sewage treatment plants are most likely to benefit from implementation of ESSS programs.

. The decision to implement an ESSS program in any municipality should be based on local conditions.

. All municipal sewer use bylaws should establish the authority to implement an ESSS program.

. ESSS program design should emphasize simplicity and ease of implementation.

. ESSS program implementation should be accomplished with input from affected sewer users.

EXECUTIVE SUMMARY

Introduction

This study of the extra-strength sewer surcharge (ESSS) was undertaken in support of the Ontario Ministry of the Environment initiative to control toxic contaminants, entitled the Municipal-Industrial Strategy for Abatement (MISA). The ESSS is a charge paid to municipal sewage authorities by industrial users of sanitary sewers. The distinct feature of ESSS charges is that they increase as waste strength increases beyond a designated threshold. ESSS charges provide an economic incentive to dischargers to reduce waste strength.

The goal of this study is to contribute to the evaluation of sewer use control options by providing a detailed investigation and critique of the use and effectiveness of ESSS programs in Canada. Associated objectives are:

- to document the existence and application of extra-strength sewer surcharges in Canada;
- to evaluate the effectiveness of these sewer surcharges; and
- to provide input to Ontario municipal sewer use control strategies.

A literature review, a major national survey of municipal sewage authorities, and subsequent interviews and data analyses were completed to fulfill these objectives.

Thirty-three out of 192 municipalities or regional municipalities responding to the national survey reported having ESSS programs. Of these, 26 had programs that were actually implemented. While this number represents only 14% of respondents, municipalities with these programs were relatively large, accounting for 59% of the service population of all respondents.

Municipalities with ESSS programs tended also to have more advanced treatment systems (primarily secondary or tertiary) and greater numbers of industrial accounts than other responding municipalities. By the same token, ESSS programs were found in municipalities having a higher incidence of problems with industrial sanitary discharges and more extensive overall regulatory programs in response to these problems.

ESSS programs have been used in Britain and the United States since at least the 1930's and were first adopted in Canada in the 1950's. Existing programs vary considerably from one municipality to the next in terms of the type of rate structure, coverage of the program and charge levels; however, all programs have certain basic features in common, including:

- a formula and rates for determining charge levels;
- a means of identifying who is to be charged;
- a method for determining the strength of chargeable wastewater.

Most existing programs focus on larger high-strength waste dischargers and are concerned with the discharge of BOD (or COD), solids, grease and oil. Study findings relate primarily to these conventional wastewater parameters.

Advantages and Disadvantages of ESSS Programs

Inducement to industry to install pre-treatment is a major objective of ESSS programs. This objective has been realized by existing programs. Survey responses suggest that one fifth of monitored establishments installed pre-treatment while 41% of these establishments responded positively in this or other ways (eg. improved housekeeping).

This positive response is not entirely motivated by economic considerations since ESSS charges are generally below the cost of effluent pre-treatment systems. While low cost remedial measures are definitely available to industry, it is as likely that establishments are responding to the combined pressure of a regulatory program that includes the ESSS.

Favourable municipal impacts were reported by two-thirds of survey respondents. These range from improvements in the quality of influent received by sewage treatment plants through to cost savings related to operations and capacity requirements.

Municipalities also seem to benefit financially from ESSS programs, even though revenue generation was not cited as a major program objective. The average municipal ESSS program revenue, amounting to $380,000, amounts to 14% of average treatment costs and appears to more than cover the direct costs related to administration of ESSS programs.

A more equitable allocation of treatment system costs was identified as a major objective motivating ESSS program implementation. The basic principal here is that users should pay for services that they receive. Provided that surcharge rates are determined by means of a careful evaluation of treatment systems costs and that wastewater strengths are accurately determined, equitable cost allocation is a major advantage of ESSS programs.

The principal disadvantages of ESSS programs relate to implementation and administration. Industrial opposition to new ESSS programs can be anticipated, with complaints relating to high costs, program complexity and fairness. Moreover implementation can require a new municipal administration office, as well as placing an extra burden on municipal monitoring resources.

Summary

- ESSS programs can be an effective component of regulatory programs to control the strength of industrial discharges to sanitary sewers.

- An ESSS charge can be an effective means of equitably recovering the costs of treating high strength wastes.

- Larger municipalities with significant industrial loadings to their sewage treatment plants are most likely to benefit from implementation of ESSS programs.

- The decision to implement an ESSS program in any municipality should be based on local conditions.

- All municipal sewer use bylaws should establish the authority to implement an ESSS program.

- ESSS program design should emphasize simplicity and ease of implementation. Favorable design features include:

  1. Comprehensive coverage of all major dischargers.
  2. A simple rate structure and basis for rate setting.
  3. Inclusion of at least BOD or COD and solids in the rate structure with consideration given to other parameters.
  4. Charging based on the entire pollutant load rather than loads exceeding a threshold level.
  5. ESSS rate levels that are related in a clear manner to treatment costs associated with chargeable wastewater constituents.
  6. Use of both capital and operating costs in setting ESSS charge rates.

Recommendations

- A model sewer-use bylaw drafted under MISA should include provisions establishing municipal authority to implement an ESSS program.

- Provincial guidelines concerning the design of ESSS rate structures and the calculation of rate levels should be developed in consultation with representatives from municipal sewage authorities.

- A periodic provincial sewer-use rate survey should be conducted to inform involved agencies and industry of prevailing practises and to facilitate municipal ESSS program planning exercises.

- A detailed case study evaluation of treatment system costs and accounting practices should be conducted in support of rate structure guideline development. This study should determine the feasibility and desirability of charging for toxics.

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Finally, a sincere thanks must go out to all those municipal staff who endured our questionnaire, follow-up calls and, in certain cases, our interviews. We know that Ontario staff in particular are being subjected to numerous surveys and other queries for information as a result of MISA.

1.0 INTRODUCTION

1.1 MISA Program

In June of 1986, the Ontario Ministry of the Environment announced the Municipal-Industrial Strategy for Abatement (MISA). The goal of MISA is the "virtual elimination of toxic contaminants" that are being discharged to surface waters by municipalities and industry.

A number of studies have been launched as a result of the MISA initiative with the objective of developing an abatement program to regulate the discharge of toxic contaminants at source. Included are studies to characterize wastewater discharges, identify priority pollutants, develop regulations, and identify and evaluate control options.

The Sewer Use Control Program proposed under MISA concerns the control of industrial discharges to Municipal sanitary sewers. One of the control options being considered for this program, the extra-strength sewer surcharge (ESSS), is the subject of this study. The ESSS is a charge paid by industrial users of sanitary sewers that increases as the concentration of targeted contaminants in their wastewater increases beyond a designated level. The ESSS therefore functions by providing an economic incentive to reduce waste strength.

The principal feature of the ESSS is the linkage established between the user fee for sanitary sewers and the strengths of wastes being discharged. This feature distinguishes the ESSS from the customary municipal sewer charge or surcharge that increases with the volume of discharged wastewater but not its strength.

1.2 Industrial Sewer Use Regulation

In Ontario nearly 20,000 industrial establishments discharge their wastewaters to municipal sewer systems. These industrial effluents vary substantially in both quantity and degree of contamination and may in certain instances:

- Interfere with collection and treatment systems operation.
- Result in the discharge to ambient waters of toxic contaminants.
- Impair sewage sludge quality.

Specific problems associated with improper industrial discharges to sanitary sewers are outlined in Table 1.1.

Environmental degradation is a primary concern when industrial sanitary discharges have an adverse impact on the quality of effluent from municipal treatment plants. In addition, however, problems related to industrial sanitary discharges can have a significant economic impact on treatment plant operations by decreasing the useful life of system components, increasing capacity requirements and increasing operating costs for instance for sludge disposal.

The role of the Ontario Ministry of the Environment in sewer use management has, until recently, been advisory. The Ministry has provided technical guidance to the municipalities through its input to the development of "model" sewer-use bylaws. The enactment and enforcement of bylaws is however under municipal jurisdiction.

Although municipal regulatory mechanisms are in place in Ontario they are by no means universally effective nor necessarily consistent with the goals of MISA. In particular:

- Significant variability in surcharge and general sewer use bylaw implementation by municipalities has resulted in major differences in criteria, enforcement, prosecution, and industry abatement costs across municipalities.

TABLE 1.1

PROBLEMS ASSOCIATED WITH INDUSTRIAL DISCHARGES TO MUNICIPAL SEWERS

Main Category	Specific Causes
Interference with proper operation of collection and treatment facilities.	- Excessive BOD and SS discharge.
	- Discharge of substances physically blocking or clogging collection and treatment facilities
	- Discharge of substances producing excessive foaming in collection and treatment facilities.
	- Discharges of substances with toxic impact on treatment facility biomass (aerobic or anaerobic).
	- Discharges of substances producing various udders and/or toxic gases.
	- Discharges resulting in excessive physical deterioration (e.g. corrosion) of collection and treatment systems.
	- Excessive hydraulic discharges.
	- Discharges of oils, greases and similar substances resulting in multiphase flow and coating of collection and treatment facilities.
	- Discharge of effluents of excessive temperature.
Discharge of toxic contaminants to receiving waters.	- Discharge of toxic substances that are not removed or partially removed by conventional WPCP's into collection systems. This is the so-called "pass-through" problem.
Impairment of sewage sludge quality and possible impacts on land productivity and food production.	- Discharge of toxic substances that are not degraded or partially degraded by sludge digestion and that accumulate in sludge streams.

- The current bylaw criteria governing concentrations of contaminants in sanitary discharges do not address a lengthy list of organic contaminants of concern, while existing surcharge schemes are even more limited in coverage.

- The existing bylaws do not per se address problems of sludge impairment and "pass-through" but are rather founded on concepts of interference with operation.

- Smaller municipalities often do not possess the resources to mount effective programs.

- Where surcharges are not used, bylaw limits are concentration based and hence may not effectively control loadings.

Past studies have examined the ESSS and other regulatory mechanisms to control pollution (Peat, Marwick and Partners, July 1983; Donnan and Victor, 1974). These studies provide some evidence regarding the efficacy of the ESSS but they are not up to date, they do not document the extent to which ESSS programs are implemented in Ontario or Canada and they are not detailed enough to answer salient questions regarding the use of the ESSS as an economic incentive mechanism within MISA (Ontario Ministry of the Environment, 1987).

1.3 Objectives of this Study

In light of new requirements resulting from MISA implementation and an ongoing need to improve pollution control policy, the Ministry of the Environment has sponsored the current study on the ESSS.

The goal of this study is to contribute to the evaluation of sewer use control options by providing a detailed investigation and critique of the use and effectiveness of ESSS programs in Canada. Associated objectives are:

- to document the existence and application of extra-strength sewer surcharges in Canada,

- to evaluate the effectiveness of these sewer surcharges,

- to provide input to Ontario municipal sewer use control strategies

1.4 Approach to the Study

At the outset of the study, an extensive literature search was conducted using bibliographic databases available through the Industrial and Business Information Service (IBIS) of the University of Waterloo. Databases that were accessed include:

- AQUAREF (National Science Library, Ottawa, includes WATDOC)
- ENVIROLINE
- AQUALINE (British Water Resources Branch)
- PAIS (Public Affairs Information Service)
- CODOC (listing of documents in Ontario research libraries)

An annotated bibliography covering pertinent literature is provided as Appendix A.

Phone interviews were then conducted with provincial agency staff across the country to identify:

- practices that are commonly used in each province to control industrial sanitary discharges
- legislation and regulations governing the use of surcharges and other regulatory instruments in each province
- unique jurisdictional features that may affect regulatory practices (e.g. provincial operation of WPCP's, allocation of responsibility for monitoring, etc.)
- municipalities in each province that are known to use a surcharge.

A nation-wide survey of municipalities carried out as part of this study was a major primary data collection effort. It served as the main source of ESSS program information concerning:

- rationale for ESSS programs (revenue generation, cost recovery, pollution abatement incentives)
- surcharge program rate structure, formulas and levels
- surcharge application criteria (contaminant levels, type of contaminants, flow volumes, etc.)

- administrative procedures, costs and revenues
- reaction of firms (e.g. number facing surcharge levy, number installing treatment or process changes, etc.)
- collection and treatment system impacts
- descriptions of related environmental policy instruments such as licensing, discharge guidelines in bylaws, regular sewer use charges and water charges.

The survey was conducted using a mailback questionnaire that was sent to the engineering or works department of Canadian Municipalities identified on a mailing list generated from the MUNDAT database of Environment Canada's report "National Inventory of Municipal Waterworks and Wastewater Systems in Canada, 1986." This listing was meant to cover all municipalities thought to be offering sanitary services and to have service populations in excess of 5,000. The survey form, methodology and summary statistics for individual questions are provided in Appendix B. Salient features of the method include a follow-up mailing to all non-respondents after six weeks and a call to all Ontario non-respondents thought to have ESSS programs after eight weeks.

Despite follow-up efforts, questionnaires were relatively slow coming back. Questionnaire length and detail were no doubt part of the reason for this. The presence of detailed questions may also explain the partial response rates obtained for sections of the questionnaire - many municipalities, especially smaller ones, did not provide the requested information.

The total population in surveyed municipalities is that portion of the Canadian population that live in municipalities with 5,000 or more people and that are provided with municipal sewage collection and treatment services. The total 1986 population of Canada is 22,032,162 (1986 Census). The above noted 1986 inventory of waterworks and wastewater systems includes 3,650 municipalities and covers 88% of the total Canadian population with the unsurveyed population

living primarily in rural areas. Based on the data from this inventory our targeted survey population included 546 municipalities with a total population of 14.1 million.

Overall questionnaire response rates are provided in Table 1.2. Completed questionnaires were received from 40% of the target municipalities. A number of respondents had service populations below 5,000 or did not provide sanitary services (and thus would not be concerned with sewer use controls). These respondents were eliminated from the data set leaving 192 respondents with a total service population of 10.5 million for purposes of analysis. The ESSS municipal survey sample data set therefore represented 35% of eligible municipalities and 75% of the total serviced population.

Following the questionnaire survey, six Ontario municipalities were selected for follow-up interviews to collect detailed information on compliance. In particular, the operating authority staff were asked to identify individual firms levied with a surcharge, the total surcharge imposed, each firm's discharge characteristics, and the response of each firm to the surcharge (the interview form is provided in Appendix C). Data was collected for 28 industrial establishments distributed as follows:

Miscellaneous food processing	12
Brewery/winery	5
Meat products	4
Dairy	2
Textiles	1
Miscellaneous metal production	3
Laundry	1

In addition to the primary data collection efforts noted above, secondary data sources on treatment costs were used in an economic analysis of surcharge programs.

TABLE 1.2

MUNICIPAL QUESTIONNAIRE RESPONSE RATES

JURISDICTION		MARITIMES	QUEBEC	ONTARIO	PRAIRIES	BR.COL.	TERRITORIES	CANADA
Original mailing to [1] municipalities with population >5000		52	113	213	91	74	3	546
No response received [2]	No.	33	67	85	43	43	1	272
	%	63.5%	59.2%	39.9%	47.3%	58.1%	33%	49.8%
Blank questionnaires returned (declined to respond)	No.	5	5	30	8	7	0	55
	%	9.6%	4.4%	14.0%	8.8%	9.5%		10.1%
Completed questionnaires returned (total respondents)	No.	14	41	98	40	24	2	219
	%	26.9%	36.2%	46.0%	44.0%	32.4%	67%	40.1%
Completed questionnaires [3] from respondents with sanitary sewers	No.	10	25	94	40	21	2	192
	%	19.2%	22.1%	44.1%	44.0%	28.4%	67%	35.1%

Note: [1] These are the municipalities on the MUNDAT mailing list plus 9 Regional Municipalities in Ontario not on this list.

Using published cost data for representative waste discharges and removal efficiencies, estimated surcharge costs facing industrial establishments were compared to the costs of reducing pollutant concentrations or loadings to avoid the surcharge. Costs for pre-treatment at the source were also compared to representative costs for treatment of extra-strength wastes at central municipal treatment plants. Both of these costs were compared to observed surcharge rates to see if existing surcharge programs are promoting a cost-minimizing pollution abatement response on the part of sewer users.

Further evaluations of technical performance, administrative and implementation criteria and equity were based largely on municipal questionnaire data.

1.5 Organization of the Report

The following chapter discusses the current level of use of the ESSS, characterizes municipalities using the ESSS and describes salient features of ESSS programs. Chapter 3 presents the economic analysis of industrial pre-treatment and municipal treatment costs relative to surcharge rate levels. Chapter 4 discusses the advantages and disadvantages of ESSS programs. A summary and recommendations are provided in Chapter 5.

2.0 OVERVIEW OF EXISTING PRACTICES

2.1 Background

Charges for the use of sanitary sewers can encompass various types of charging mechanisms such as flat fees, tax levies, fees based on the volume of water consumed or discharged and fees based on the pollutant concentration or strength of discharges to sanitary sewers. Such charges are used to recover the costs of collecting and treating sanitary wastes.

The practice of charging for sewage services goes back to the turn of the century in the United States (Lake, Hanneman and Oster, 1979). In the United Kingdom, the treatment of industrial effluents was the subject of the British Royal Commission on Sewage Disposal from 1898 to 1915 (Harkness, 1984). This Commission recommended that local authorities should have the right to charge manufacturers discharging wastes to sanitary sewers.

Initially, in the United Kingdom, charges for industrial effluents were proportional to discharge volume. In 1936, with the opening of the Modgen Works treatment plant in West Middlesex, an effluent charge based on quantity and quality was introduced (Ingold, Stonebridge, 1987). By 1976, existing practices of various local authorities were codified in the form of national guidelines for control and charging related to industrial effluents. These guidelines were drafted by the Confederation of British Industry and the National Water Council. British Regional Water Authorities, empowered by the 1974 Control of Pollution Act, now control virtually every industrial effluent discharged to sanitary sewers in Britain and can impose charges that are set to recover "the actual cost of reception and treatment of industrial effluent" (Sidwick, 1982).

While there is not the same degree of centralization and standardization in the United States as is evident in the United Kingdom, control and charging for industrial effluents are nevertheless promoted at the federal level by 1972 amendments to the Water Pollution Act that govern cost sharing arrangements for Federal grant facilities. Objectives of EPA regulations under this act are (Taylor, 1972):

- to distribute costs in proportion to benefits received;
- to assure financial capability to construct and operate facilities;
- to promote awareness of treatment costs;
- to promote volume and loading based costs; and
- to encourage self-sufficiency in sewage services.

Surveys that predate this amendment found that 20% of the reporting United States cities had provisions for an ESSS in their bylaws while less than 10% had actually implemented an ESSS (Public Works Engineer, 1955; Lake, Hanneman and Oster, 1979). In a more recent survey, two thirds of respondents were found to be using an ESSS (Technical Practice Committee, 1982).

While there exist significant variations in programs across national boundaries and across municipalities, all ESSS programs must nevertheless have certain basic features in common, namely:

- a formula for determining charge levels that identifies chargeable waste water constituents and associated charge rates;
- criteria for determining which firms are to be charged; and
- a means of assigning waste strength values to industrial discharges for purposes of charging.

2.2 Current Level of Use of the Extra-Strength Sewer Surcharge in Canada

The evaluation of existing Canadian use of the ESSS is based on questionnaire data for those 192 respondents indicating the presence of

sewage service within their jurisdiction. Of this total 33 report having a surcharge program in place. This represents 17% of the reporting municipalities; the associated 95% confidence interval based on a test of proportions is 14.8% to 19.9%. These programs are not evenly distributed across the country, being concentrated in Ontario and the Prairies (Table 2.1). (Information describing salient features of individual ESSS programs is provided in Appendix F while summary statistics for the ESSS municipal survey are provided in Appendix B, Table B.1.)

Not all municipalities with ESSS programs instituted in their bylaws actually monitor the effluent of eligible industrial clients. Across Canada, 26 of the 33 reporting municipalities with programs in place actually monitored industry (Table 2.1); the remainder, in effect, have not implemented their ESSS programs.

This tendency to have a surcharge agreement instituted in the bylaw without actually implementing the program may be more prevalent than is indicated by questionnaire responses. A review of 78 bylaw documents from municipalities in Ontario revealed provisions for surcharging in 45 cases (personal communication, B. Leclair, Ministry of the Environment). Thirty-four of these 78 municipalities responded to the ESSS municipal survey. All of these respondents indicated that there were surcharge provisions in their bylaws; however, based on information on monitoring and ESSS charging activity, only 14 appeared to have implemented an ESSS program. Similar findings were obtained in a survey of 1160 U.S. cities; 20% of these allowed for surcharging but only 5% actually used the surcharge (Lake, Hanneman and Oster, 1979).

Municipalities reporting a surcharge program form a distinct subset of reporting municipalities. Secondary or tertiary treatment systems are used by 88% of these municipalities as opposed to 55% for those not using the ESSS. Municipalities with the ESSS also tend to have a larger service population with more industrial accounts (Table 2.2); and, in fact,

TABLE 2.1

USE OF AN EXTRA-STRENGTH SURCHARGE PROGRAM
BY QUESTIONNAIRE RESPONDENTS

JURISDICTION	MARITIMES	QUEBEC	ONTARIO	PRAIRIES	BR. COL.	CANADA
Number of Responding Municipalities						
Total number responding	10	25	94	40	21	192
Mun's with program in place[1]	1	1	15	14	2	33
(% of total)	10.0%	4.0%	16.0%	35.0%	9.5%	17.2%
Mun's with program implemented[2]	0	1	15	8	2	26
(% of total)	0.0%	4.0%	16.0%	20.0%	9.5%	13.5%
Service Population of Responding Municipalities						
Total for all municipalities	64,340	263,520	8,220,500	1,394,430	541,550	10,499,330
For mun's with program in place	15,000	38,000	4,850,400	1,217,250	54,200	6,174,850
(% of total)	23.3%	14.4%	59.0%	87.3%	10.0%	58.8%
For mun's with program implemented	0	38,000	4,850,400	1,216,810	54,200	6,159,410
(% of total)	0.0%	14.4%	59.0%	87.3%	10.0%	58.7%

NOTES: [1] Counts based on numbers of municipalities who provided information describing their ESSS programs (questions in Section 3A and 4, Appendix B questionnaire form)

[2] Counts based on numbers of municipalities who reported monitoring and charging activity under an ESSS program (questions 45 and 46, Appendix B questionnaire form)

SOURCE: Extra Strength Sewer Surcharge Municipal Survey

TABLE 2.2

CHARACTERISTICS OF MUNICIPAL SEWERAGE SERVICES

	ALL RESPONDENTS	RESPONDENTS WITH ESSS	RESPONDENTS WITH NO ESSS
Average Service Population	55,600	187,100	27,700
No. Responding	(189)	(33)	(156)
Average No. of Service Accounts			
Total all user classes	9,300	20,400	6,600
No. Responding	(150)	(29)	(121)
Industrial users	230	500	160
No. Responding	(87)	(19)	(68)
Frequency of Treatment by Type:			
None	3	0	3
Lagoon	58	6	52
Primary	34	8	26
Secondary or Tertiary	109	29	80
No. Responding	(179)	(33)	(146)
Average Day Effluent Flow m^3/d	40,700	147,300	16,900
No. Responding	(174)	(33)	(141)

Source: Extra-Strength Sewer Surcharge Municipal Survey.

encompass 59% of the total reported service population though representing only 17% of reporting municipalities. The proportion of industrial establishments that are within jurisdictions using an ESSS is likely to be most closely reflected by the service population data. If this is the case then the data suggests a relatively high exposure of industry to the ESSS within our survey sample.

2.3 Program Implementation

The majority of reported programs were initiated in the 1970's (18 out of 29) with the earliest programs reported by Winnipeg (1958) and Strathroy (1953). On average, the program design and implementation period lasted 17 months with industry being given almost a year of lead time (Table 2.3). The implementation period and lead time allowed industry were on average twice as long in Ontario as in the Prairies. The lead time for industry allows plant managers to adjust operations prior to charging and may improve industry receptivity to the ESSS program. In Greenboro, N.C., this adjustment was facilitated by municipal staff who assisted firms in this adjustment stage (Shaw, 1970).

In half of the reporting municipalities, an information program was mounted for industry to introduce the program and input was solicited from industry (Table 2.3). These practices were more common in Ontario, perhaps explaining the longer implementation periods there. The need for good communication with industry during program implementation may be worth the delays and other costs that result; at least this is the conclusion of two authors documenting case studies in Winnipeg and New Jersey (Bubbis, 1963; Mount, 1979).

TABLE 2.3

SURCHARGE PROGRAM IMPLEMENTATION

JURISDICTION	ONTARIO	PRAIRIES	OTHER	CANADA
Year of Establishment				
Average	1971	1975	1983	1974
Latest	1981	1987	1986	1987
Earliest	1953	1958	1977	1953
(no. responding)	15	13	3	31
Average Implementation Period (mo.)	22	11	12	17
Reported Frequency of Reasons Cited for Implementation				
Revenue generation	1	2	1	4
Fair cost allocation	11	7	2	20
Penalize dischargers	5	6	2	13
Promote pre-treatment	10	8	3	21
Other	1	4	0	5
(no. responding)	14	14	4	30
Average Lead Time Given to Industry Before Implementation (mo.)	12.6	6.3	14	11.1
(no. responding)	13	6	3	22
Respondents Using an Information Program for Industry to Help with Implementation				
Program used	10	3	2	15
No program used	4	7	2	13
Respondents Seeking Industry Input During Program Design Phase				
Input sought	10	3	1	14
No input sought	5	8	2	15

Source: Extra Strength Sewer Surcharge Municipal Survey

2.4 Program Objectives

Reported surcharge programs were implemented for a variety of reasons (Table 2.3). Two thirds of respondents identified as an objective the fair allocation of treatment cost. In this context, a fair cost allocation refers to the allocation of costs to users or user groups in proportion to the total benefit received in terms of sewage services. These services include a range of features related primarily to sewage conveyance and to treatment. Treatment services relate in turn to both the quantity and quality of sewage treated, and it is the quality dimension of treatment service that will be more equitably reflected in charges which include an ESSS.

ESSS program charges that are set to achieve a fair cost allocation - where fair means "in proportion to service received" - are consistent with user-pay pricing principles supported by the Inquiry on Federal Water Policy (Pearse, Bertrand, Maclaren, 1985). Fee-for-service pricing principles also find support in economic arguments for an efficient use of scarce public resources. Economic efficiency entails an allocation of productive resources that yields greatest benefit for society. In the context of this study, this is interpreted to mean that wastewater treatment be undertaken jointly by the private and public sector in a manner that minimizes total treatment costs (see chapter 3 below for further discussion of economic efficiency). When user fees for public sewage services are properly aligned with the costs of those services, then they send the right economic signal to the private sector regarding how much private investment should be devoted to pre-treatment.

Regulatory motives appear to be as important as cost allocation motives for ESSS programs. For example, as many respondents cited promotion of pre-treatment as a motive, as did those citing fair cost allocation, while over one third of respondents indicated that the ESSS charge was a penalty for high strength wastes (Table 2.3). The focus on regulation was also

encountered during follow-up interviews with municipal staff; in the Regional Municipality of Peel, for example, there was an explicit goal of eliminating extra-strength discharges within five years. That nine out of 32 respondents reported expanding bylaw enforcement efforts while introducing the ESSS is further evidence of the regulatory orientation of sewage authorities. There was, on the other hand, very little interest expressed in revenue generation as a motive for ESSS programs.

2.5 ESSS as Part of an Overall Regulatory Strategy

ESSS programs are mounted as one component of municipal strategies to regulate industrial discharges. Conventional mechanisms for regulation include bylaw limitations on waste strength supported by a program of surveillance and enforcement. Bylaw limits must be found to be exceeded one or more times during surveillance before enforcement action is commenced. On average, just under four violations are required to trigger such action (Table 2.4).

Overall, municipalities with ESSS programs in place also tend to have a more extensive general program of industrial regulation. For instance, 15% of municipalities with an ESSS report no program for detection of bylaw violation while over 40% of those without the ESSS have no such program (Table 2.4). Similarly, a greater number of municipalities with the ESSS report using mechanisms such as negotiations, warnings and prosecution to enforce the bylaw limits when violations are detected. "Other" enforcement mechanisms that are reported include severance of service and invoicing users for extraordinary costs incurred due to high strength wastes.

The more active stance of municipalities with the ESSS is also reflected in the intensity of surveillance efforts to detect bylaw infractions - on

TABLE 2.4

BYLAW ENFORCEMENT MECHANISMS

JURISDICTION	MARITIMES	QUEBEC	ONTARIO	PRAIRIES	BR. COL.	OTHER	CANADA
Number of municipalities reporting various mechanisms for bylaw violation detection							
no program in place	4	4	16	8	4	0	36
plant inspections	1	2	29	7	2	0	41
discharge sampling	1	6	42	10	3	1	63
other (complaints, surveillance by other agencies)	0	2	7	4	1	0	14
(tot. no. responding)	5	10	62	21	7	1	106
Number of BOD/SS samples required to trigger enforcement							
average	-	-	3.8	3.0	-	-	3.7
maximum	-	-	25.0	4.0	-	-	25.0
minimum	-	-	1.0	2.0	-	-	1.0
(tot. no. responding)	0	0	29	5	0	0	34
Number of municipalities reporting various mechanisms for bylaw enforcement							
warnings and negotiations	2	4	39	14	5	0	64
prosecutions and fines	0	1	18	4	1	0	24
provincial orders	1	0	6	2	1	1	11
bylaw not enforced	1	1	4	3	1	0	10
no need for enforcement yet	2	5	16	4	1	0	28
other (disconnect service, special charges)	0	0	4	1	0	0	5
(no. responding)	5	10	60	20	7	1	103

cont'd ...

TABLE 2.4 - cont'd

BYLAW ENFORCEMENT MECHANISMS

JURISDICTION	ONTARIO		PRAIRIES		OTHER		CANADA	
	ESSS	NO ESSS	ESSS	NO ESSS	ESSS	NO ESSS	ESSS	NO ESSS
Number of municipalities reporting various mechanisms for bylaw violation detection								
no program in place	0	16	4	4	1	11	5	31
plant inspections	13	16	5	2	2	3	20	21
discharge sampling	15	27	9	1	3	8	27	36
other	2	5	3	1	1	2	6	8
(tot. no. responding)	15	47	14	7	4	19	33	73
Number of BOD/SS samples required to trigger enforcement								
average	2.8	4.8	3.0	-	-	-	2.8	4.8
maximum	7.0	25.0	4.0	-	-	-	7.0	25.0
minimum	1.0	1.0	2.0	-	-	-	1.0	1.0
(tot. no. responding)	14	15	5	0	0	0	19	15
Number of municipalities reporting various mechanisms for bylaw enforcement								
warnings and negotiations	12	27	11	3	2	9	25	39
prosecutions and fines	10	8	4	0	1	1	15	9
provincial orders	1	5	1	1	1	2	3	8
bylaw not enforced	0	4	2	1	1	2	3	7
no need for enforcement yet	2	14	3	1	1	7	6	22
other (disconnect service, special charges)	2	2	1	0	0	0	3	2
(tot. no. responding)	15	45	14	6	4	19	33	70

Source: Extra Strength Sewer Surcharge Municipal Survey

average they monitor one firm out of every 3.4 industrial clients on their systems, as opposed to one out of every 26.6 industrial clients in towns or cities with no ESSS.

2.6 Program Coverage

Actual application of the charge formula requires that the sewage authority identify who is eligible for charging. Survey respondents were almost unanimous in indicating that all high strength dischargers were included in their programs.

There are, however, various means of identifying who these dischargers are. In Winnipeg, for example, establishments in 16 industries have their discharge monitored by the city (Penman, 1974). Large sources are treated in a similar manner in Greenboro, N.C., but smaller industrial sources, such as laundrys, are also brought into the ESSS program with charging of these based on representative waste strengths for classes of dischargers (Shaw, 1970). Both New York and Los Angeles County also include classes of smaller dischargers and assume representative waste strengths for clients in these classes (Anonymous, 1971; Kremer and Glasgow, 1979).

For program coverage to be based on wastewater strength or on membership in a high waste strength industrial sector there is usually a threshold for contaminant concentration below which waste strength is considered acceptable. Los Angeles County does not use such a threshold in its charge program; neither does Chicago (Anderson and Sosewitz, 1971). In the absence of a lower threshold, all industrial dischargers are eligible for ESSS charging. Chicago avoids this outcome by use of a discharge volume threshold instead of a concentration threshold below which the ESSS does not apply. Dischargers of small volumes are exempt with a volume threshold in place.

TABLE 2.5

BYLAW ENFORCEMENT ACTIVITY

JURISDICTION	MARITIMES	QUEBEC	ONTARIO	PRAIRIES	BR. COL.	CANADA
Number of establishments under inspection						
average	4	4	99	13	4	71
maximum	-	10	1817	60	10	1817
minimum	-	1	1	1	1	1
(no. responding)	1	4	39	9	4	57
Number of violators dealt with in 1986						
average	1	-	10	2.6	1.5	8.6
maximum	-	-	63	5	2	63
minimum	-	-	1	1	1	1
(no. responding)	1	0	27	3	2	33
Number of prosecutions in 1986						
average	-	-	33	1	-	28
maximum	-	-	163	-	-	163
minimum	-	-	1	-	-	1
(no. responding)	0	0	5	1	0	6
Average fine in 1986						
average	-	-	$ 3,296	$ 7,500	-	$ 3,997
maximum	-	-	$14,500	-	-	$14,500
minimum	-	-	$ 50	-	-	$ 50
(no. responding)	0	0	5	1	0	6
Maximum fine in 1986						
average	-	-	$ 1,800	$12,500	-	$ 4,475
maximum	-	-	$ 2,400	-	-	$12,500
minimum	-	-	$ 1,000	-	-	$ 1,000
(no. responding)	0	0	3	1	0	4

cont'd ...

TABLE 2.5 - cont'd

BYLAW ENFORCEMENT ACTIVITY

JURISDICTION	ONTARIO		PRAIRIES		CANADA	
	SURCHARGE	NO SURCHARGE	SURCHARGE	NO SURCHARGE	SURCHARGE	NO SURCHARGE
Number of firms under inspection						
average	246	7	13	-	147	6
maximum	1817	36	60	-	1817	36
minimum	2	1	1	-	1	1
(no. responding)	15	24	9	0	26	31
Number of violations dealt with in 1986						
average	17	3	3	-	13	3
maximum	63	15	5	-	63	15
minimum	1	1	1	-	1	1
(no. responding)	13	14	3	0	17	16
Number of prosecutions in 1986						
average	55	1	1	-	42	1
maximum	163	-	-	-	163	1
minimum	1	-	-	-	1	1
(no. responding)	3	2	1	0	4	2
Average fine in 1986						
average	$ 643	$ 7,275	$ 7500	-	$ 2,357	$ 7,275
maximum	$1,000	$ 14,500	-	-	$ 7,500	$ 14,500
minimum	$ 250	$ 50	-	-	$ 250	$ 50
(no. responding)	3	2	1	0	4	2
Maximum fine in 1986						
average	$1,800	-	$12,500	-	$ 4,475	-
maximum	$2,400	-	-	-	$12,500	-
minimum	$1,000	-	-	-	$ 1,000	-
(no. responding)	3	0	1	0	4	0

Source: Extra Strength Sewer Surcharge Municipal Survey

2.7 Determining Wastewater Strengths

It is already noted above that wastewater strength can be determined from monitoring data or, where no monitoring is done, representative values can be assumed. Twenty-five of 31 Municipal Survey respondents with an ESSS rely entirely on monitoring, while only one uses only representative data and five use both.

In all but one case (32 out of 33) the municipal sewage authority is responsible for sampling. Dischargers engage in sampling in 6 municipalities, and assume primary responsibility for installation of manholes or other access facilities for sampling purposes. In the majority of cases (16 out of 21), auditing of sample results is done by the municipality. In Windsor, municipal samples are split in certain cases to allow firms to verify municipal results.

Two-thirds of the respondents report that sampling for the ESSS program also serves as the principal sampling effort used to detect bylaw violations. This could result in certain inefficiency since bylaw enforcement requires detection of peak concentrations while ESSS charges are usually intended to reflect average concentrations (exceptions are the Regional Municipalities of Niagara and Hamilton-Wentworth which use maximum values).

The average number of samples collected in total for documented ESSS programs is 260/year, while average sampling frequency per establishment is 36.6 samples/year. The Ontario average, 21.4 samples/year, is considerably lower than in the Prairies at 55.9/year; this difference could not be explained. The maximum reported sampling frequency for any single firm was 300 samples/year in Halton. Composite sampling (8 and 24 hour) makes up 60% of total samples collected.

2.8 Program Size

A total of 400 firms are monitored under ESSS programs covered by the ESSS Municipal Survey. This is an average of 12 per municipality. In 15 cases, 10 or fewer firms are monitored, in 3 cases more than 30 are monitored and the maximum number in any one program is 84 in Metro Toronto. On average, a surcharge fee is levied against 87% of these monitored firms. Half of the respondents charged all the firms that were being monitored in their programs.

2.9 Rate Structure

Most surcharge formulas use the basic format of a charge rate (R) per unit volume of sanitary discharge (Q) multiplied by a factor that is a function of waste strength (C). This function is directly related to concentration or to a ratio of observed and allowable concentrations. Concentration is often measured in the formula as the excess of a bylaw limit (i.e. $C-C_L$) though in certain cases total concentration is used (just C). The combination of flow and concentration in the formula effectively means that charges are based on pollutant loadings since load equals the product (CQ).

Among the documented rate structures, the following specific ESSS rate formulas were encountered:

	No. of Municipalities
a) excess concentration divided by allowable concentration $QR(C-C_L)/C_L$ for $C > C_L$	12
b) excess concentration $QR(C-C_L)$ for $C > C_L$	13
c) total concentration QRC	3

Sewage constituents considered in charge formulas used by questionnaire respondents are BOD, SS, and 'grease plus oil' in the following combinations:

	No. of Municipalities	
BOD only	3	
SS only	1	
BOD and SS	15	(including 5 also using parameters such as PO_4, phenols, and COD)
SS and grease	1	
BOD, SS, grease and oil	11	(including one with PO_4 and one with phenols in the formula)

These parameters are consistent with the literature, where documented formulas typically include BOD and SS but other constituents are also reported such as COD, metals, cyanide, chlorine demand and hydrogen ion concentration, ammonia, oil and grease, and maximum flow (Public Works Engineer, 1955; Ingold and Stonebridge, 1987; Technical Practice Committee, 1982).

To illustrate the application of ESSS formula consider a simple case involving one strength parameter, BOD, with a surcharge threshold of 300 mg/l. An effluent discharge of 10,000 m^3/year with a BOD concentration of 800 mg/l would result in the following annual ESSS charges:

formula (a) $(10{,}000\ m^3)\ (\$0.20/m^3)\ (800 - 300)/300$

$= \$\ 3{,}333$

formula (b) $(10{,}000\ m^3)\ (\$0.02/mg \cdot m^3)\ (800 - 300)$

$= \$100{,}000$

formula (c) $(10{,}000\ m^3)\ (\$0.02/mg \cdot m^3)\ (800)$

$= \$160{,}000$

To illustrate a multiple parameter case, add SS to the above example at a limit of 350 mg/l and an effluent concentration of 1,200 mg/l. The case for formula (a) becomes:

$$(10,000\ m^3)\ (\$0.20/m^3) \times [\underline{0.5}\ (800 - 300)/300 + \underline{0.5}\ (1,200 - 350)/350]$$

$$= \$4,095$$

Here the underlined values (= 0.5) introduced into the formula are cost apportionment factors discussed in Section 2.11.

None of the reporting municipalities used a formula based on the ratio of observed and allowable concentrations (C/C_L). A form of this formula, called the Mogden formula, is widely used in Britain (Ingold and Stonebridge, 1987).

The following formulas are representative examples of the three noted above (BOD, SS, etc. in mg/l):

a) excess concentration divided by allowable concentration as used in:
Waterloo Region, Ontario

Q x (\$.40/1000 gal) x
[0.5(BOD-300)/300 + 0.5(SS-350)/350 + (phenol-1)/1]

Peel Region, Ontario

Q x (\$.21/m^3) x
[max. of (BOD-500)/500, or (SS-600)/600, or (grease-150)/150]

b) excess concentration as used in:
Regina, Saskatchewan

Q x (\$0.031(BOD-300) + \$0.031(SS-300)
+ \$0.027(grease-100) + \$0.060(PO_4-30)]

c) total concentration as used in:
Swift Current, Saskatchewan

Q x (\$0.042(BOD) + \$0.011(SS) + \$0.046(grease)] x (conversion factor)

The Peel Region example above illustrates the use of a maximum value approach; the formula uses the maximum of the three factors estimated for BOD, SS and grease to determine the charge level. This type of formula is used in four of the documented cases. Other variations include a surcharge formula linked to the tax assessment rather than to a discharge rate and another using an increasing block rate structure tied into excess concentrations. Three other smaller municipalities based the ESSS charge on a negotiated agreement with industrial customers.

Concentration thresholds in surcharge formulas reported by survey respondents are shown in Table 2.6. All of the threshold limit values were quite similar across municipalities, with most BOD and SS values ranging from 300 to 500 mg/l and grease and oil values from 100 to 150 mg/l. None of the threshold values used in the surcharge formulas exceeded the bylaw limit values, and in fact, in three Prairie cities, bylaw limits for BOD, SS and grease/oil exceeded the surcharge formula concentration thresholds (i.e. C_L in the formula above). Industry is not, therefore, given a free ride in the form of a loading allowance in excess of bylaw limits.

2.10 Rate Levels and Charges

Actual charge rates (i.e. R in the formulas above) reported by bylaw documents, vary considerably in terms of the units in which they are expressed. To allow a direct comparison, charge rates have been expressed in terms of pollutant loading (Table 2.7). The greatest amount of cost data is available for BOD and SS. Reported rates are seen to vary by one to two orders of magnitude across reporting municipalities. This variation is explained by differences in treatment cost, differences in the cost items included in the rate calculation, and variations in the frequency of rate updates.

TABLE 2.6

REPORTED CONCENTRATION THRESHOLDS IN SURCHARGE RATE STRUCTURES

THRESHOLD VALUE (mg/l)	FREQUENCY OF REPORTED VALUES				
	BOD	SS	GREASE & OIL	PHENOLS	PO_4
<100	-	-	2	2(=1)	1(=30)
100	-	-	5	-	-
150	-	-	3	-	-
200	2	1	-	-	-
250	1	2	-	-	-
300	16	6	-	-	-
350	-	10	1(=450)	-	-
400	-	1	-	-	-
500	6	2	-	-	-
600	-	4	-	-	-
700	1	-	-	-	-
1200	1	1	-	-	-
Mean Value	383	403	139	1	30
No. Reporting	27	27	11	2	1

Source: Extra Strength Sewer Surcharge Municipal Survey

TABLE 2.7

CHARGE RATES FOR SELECTED STRENGTH PARAMETERS
IN EXCESS OF THE THRESHOLD CONCENTRATION (cents/kg)

MUNICIPALITY	BOD	SS	GREASE	PHENOL	TKN	PO_4
Summerside	- -	442.0	1550.0	- -	- -	- -
Sussex	10.3	- -	- -	- -	- -	- -
Durham[1]	15.0	15.0	- -	- -	- -	- -
Metro Toronto	23.3	23.3	23.3	23.3	- -	- -
Peel	41.8	34.9	139.0	- -	- -	- -
Hamilton-Wentworth	23.1	19.8	- -	- -	710	- -
Niagara	23.2	23.2	- -	- -	- -	- -
Waterloo	14.6	12.6	- -	8790.0	- -	- -
Chatham	44.0	- -	- -	- -	- -	- -
Windsor (West WPCP)	30.5	30.5	30.5	- -	- -	- -
(Little R WCPC)	50.4	50.4	50.4	- -	- -	- -
Strathroy	26.7	22.9	- -	- -	- -	800.0
London	18.3	15.7	- -	- -	- -	- -
Brandon	4.1	- -	- -	- -	- -	- -
Portage La Prairie	41.8	31.5	- -	- -	- -	- -
Winnipeg	26.0	19.0	- -	- -	- -	- -
Regina	11.0	11.0	9.5	- -	- -	21.2
Swift Current[2]	4.2	1.1	4.6	- -	- -	- -
Yorkton	72.9	57.9	- -	- -	- -	- -
Saskatoon	3.2	5.5	2.4	- -	- -	- -
Medicine Hat	16.1	16.1	64.5	- -	- -	- -
Brooks[2]	59.4	47.5	- -	- -	- -	- -
Cochrane	22.0	33.0	33.0	- -	- -	- -
Innisfall	8.8	11.0	11.0	- -	- -	- -
Red Deer	18.3	20.0	5.7	- -	- -	- -
Prince George	77.0	54.0	150.0	- -	- -	- -

Note: [1] Rate varies depending on which of 2 WPCP's receives wastes
[2] Charge is based on total concentration

Source: Extra Strength Sewer Surcharge Municipal Survey

Data on the year in which the rates were set were available for 19 municipalities. Of these, 11 had set their rates in 1986 or 1987, another four had set their rates since 1980, and four reported rates set in the 1970's. The later group had the lowest reported rates.

In the majority of cases (14 of 29) rate levels are set based on collection and/or treatment system costs. A number of other respondents (8) also include surcharge program costs in the rate setting exercise, while four indicate that revenue targets were used or rate levels in other municipalities were referenced in setting rates.

All of the respondents who used system costs to set rates, included treatment system operating and maintenance costs in their calculations, while over half also considered treatment system capital costs (14 out of 22) and overhead costs (13 out of 22). Collection system costs, which are normally attributed to discharge volume only, were built into the ESSS rate setting exercises in 12 out of 22 cases.

Monthly or quarterly billing of each establishment is the norm. The average quarterly billing is $6,800; the value being within the most frequent range for quarterly billing, $2,500 to $7,500 (based on an analysis of charge levels normalized to a quarterly interval).

2.11 Distribution of Treatment Costs to Surcharge Rate Factors

Perhaps the most complex technical task in setting surcharge rates is the apportionment of component costs to each chargeable parameter. Charge rates are typically based on average unit costs for treatment. If there is only one chargeable parameter, say flow, then the charge rate for flow

would be based on total treatment costs divided by total effluent flow. With additional parameters, this simple measure of average unit cost, if applied to each parameter, would not be appropriate since it would result in charging of total treatment costs several times over. Rather, total treatment costs must be apportioned to each of the chargeable parameters in a way that accounts for all costs without at the same time leading to double counting of costs. While this cost apportionment is accomplished using different mechanisms in the surcharge formula, a commonly used method relies on an overall charge rate applied to flow and a means of increasing this charge based on concentration and cost apportionment factors (see section 2.9). The issue of how cost apportionment factors are derived is important since the basis for cost apportionment can have a significant impact on the charge faced by individual firms (Foess and Mynhier, 1983).

The most frequently encountered ESSS case is one requiring factors for discharge flow, BOD and SS. There are various treatments of this case documented in the literature which place varying emphasis on system design and system function in apportioning costs to flow, BOD and SS. A representative apportionment is provided by Ingold and Stovebridge (1987):

Flow related costs	- conveyance - primary treatment
BOD costs	- biological treatment
SS costs	- sludge treatment and disposal

Specific apportionments will vary depending on whether capital or operating costs are involved, on the treatment system configuration, and on the judgement of the engineer doing the analysis. Table 2.8 provides examples of cost apportionments from a number of sources.

TABLE 2.8

SAMPLE APPORTIONMENTS OF TREATMENT SYSTEM COSTS TO CHARGEABLE PARAMETERS (%)

System Component	Capital Costs: Roderick (1962)	Capital Costs: WPCF Task Force (1984)	Capital Costs: Boisselle, Cote (1982)	Operating: Walter (1963)	Operating: EPA (1987)	Cap. & Oper.: Anderson, Sosewitz (1971)
Grit Chamber						
Flow	100	not avail.	100	100	- -	100
BOD	- -		- -	- -	- -	- -
SS	- -		- -	- -	100	- -
Primary Clarifer						
Flow	100	100	100	70	80	100
BOD	- -	- -	- -	15	- -	- -
SS	- -	- -	- -	15	20	- -
Aeration						
Flow	not avail.	- -	- -	20	- -	- -
BOD		100	100	80	100	100
SS		- -	- -	- -	- -	- -
Secondary Clarifer						
Flow	100	100	100	50	- -	100
BOD	- -	- -	- -	50	100	- -
SS	- -	- -	- -	- -	- -	- -
Digester						
Flow	- -	- -	- -	- -	- -	not avail.
BOD	- -	50	100	20	50	
SS	100	50	- -	80	50	

Note: These apportionments are for costs that are charged through quantity/quality rates. Additional costs may be charged through tax assessments or fixed service charges.

The underlying difficulty with this sort of cost analysis exercise is that the particulate fraction of BOD and the biodegradable fraction of SS are closely associated constituents of sewage that are jointly removed at different stages of the treatment process. Treatment costs for these constituents cannot therefore be logically differentiated and any apportionment will always be somewhat arbitrary and subject to debate.

Moreover, any apportionment can introduce a degree of inequity into the charge in that industrial effluents have varying mixes of dissolved vs. particulate BOD and biodegradable vs. inorganic solids. The cost burden associated with different types of effluent will vary and may not be accurately reflected in the unit rates for BOD and SS.

In light of the complexity and uncertainty inherent in the cost apportionment exercise it is not surprising that survey responses concerning how costs are apportioned showed no clear pattern; the basis for cost allocation being:

System design considerations	- 3 respondents
Treatment system function	- 3 respondents
Design and function	- 6 respondents
Arbitrary 50/50 split	- 2 respondents
Other criteria	- 4 respondents

In the "other" category, detail was only provided for two cases in which a single cost factor was estimated and then applied to BOD or SS whichever is greater.

No discussion was provided by questionnaire respondents regarding the derivation of cost apportionment factors for parameters other than BOD and SS. There is some literature discussion regarding this question as it relates to use of the Mogden formula in the United Kingdom (Ingold and Stonebridge, 1987). The Crawley Urban District within the jurisdiction of the Thames Water Authority in England introduced cyanogen compounds as well as copper, nickel, zinc, tin and cadmium (as a total summed

concentration) into their surcharge formula as a result of problems with toxic inhibition of biological treatment processes. A separate factor was not however derived for these; rather the factor for BOD was used in an empirical manner not seemingly related to costs arising from toxic upset of processes. In Birmingham, a complicated surcharge for soluble metal salts was introduced in 1956 but dropped in 1974 "against a background of industrial recession, falling effluent metal levels, and strictly enforced consents" (Ingold and Stonebridge, 1987). A metals charge for cadmium and zinc was also introduced in London in 1979 at the Mogden works. The total charge to each establishment was based on the effluent loading of each establishment relative to total effluent loads and on the incremental cost of disposing of sludge contaminated with metals. This charge formula was criticized for being "unexplained and unacceptable".

An American case study involving a surcharge for chlorine demand is presented by Olliffe (1963). In this case, the charge rate is simply the excess chlorine demand of the effluent multiplied by the price of chlorine and a conversion factor to express the rate in terms of discharge volume.

2.12 Complexity of the Surcharge Rate

The sort of simple derivation seen above for chlorine demand is readily understood and conveyed to industrial sewer users. More complex formulations run the risk of confusing users and even operating authority staff who may accordingly become less interested in promoting use of the surcharge. For example, in follow-up calls for the municipal survey in this study, it was discovered that a surcharge rate formula in Hanover, Ontario had been dropped in favour of a fixed annual negotiated fee because of formula complexity. In Regina, staff no longer knew the rationale underlying rate factors that had been developed by previous staff. Obviously, such lack of understanding can compromise an ESSS program and should be prevented by the use of straight forward surcharge rate structures.

3.0 ECONOMIC ANALYSIS OF EXTRA STRENGTH SEWER SURCHARGE RATES

3.1 Industrial Pre-treatment

Pre-treatment costs and the alternative of paying a surcharge cost are considered as primary factors affecting pre-treatment decisions. However, decisions by plant managers regarding pre-treatment of industrial sanitary discharges will be governed by a range of other factors such as:

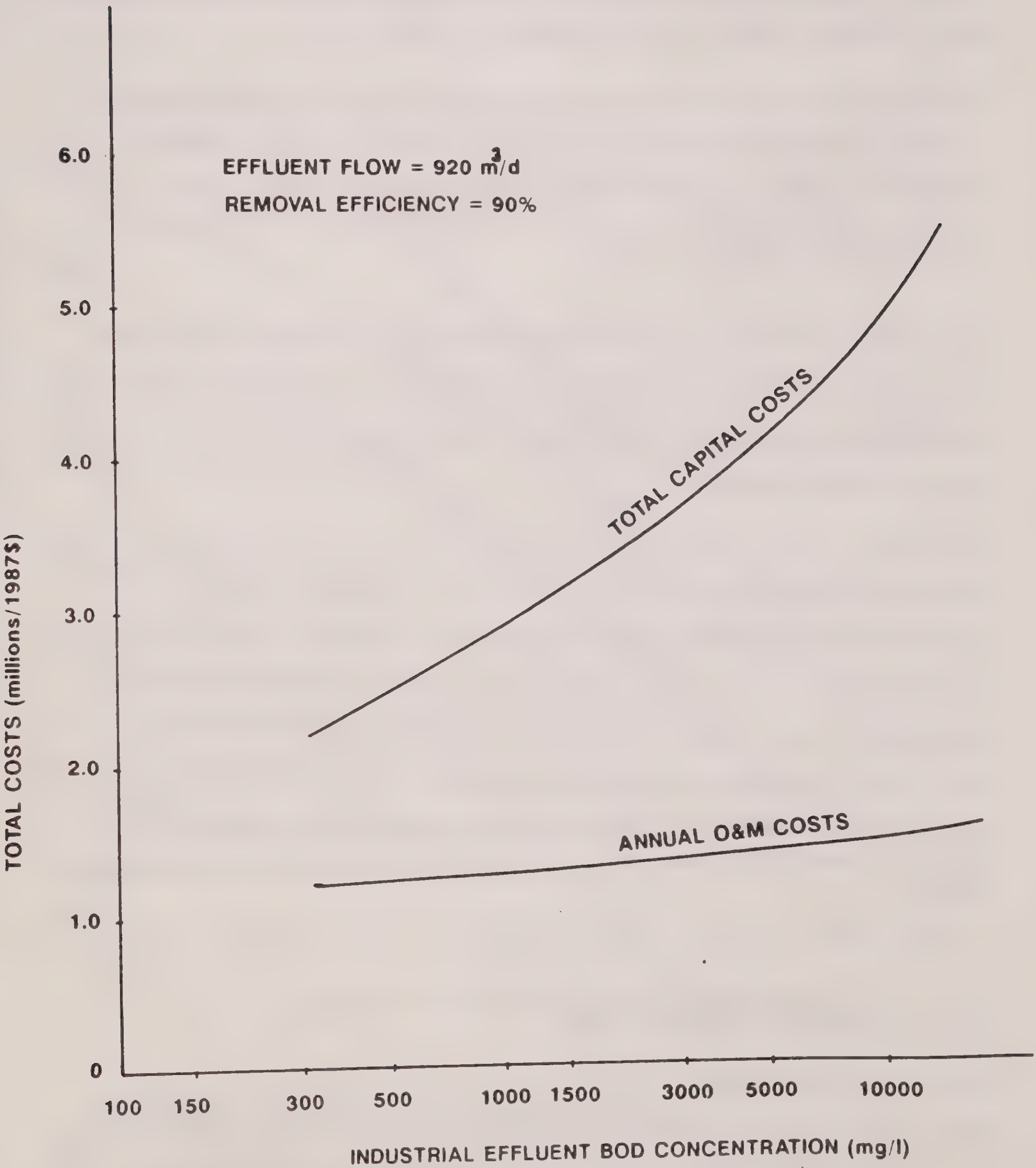
- legal and financial implications of not pre-treating,
- availability of plant labour to operate a treatment system,
- nuisance caused by the treatment system, and
- availability of land to install systems.

Pre-treatment costs were estimated for 28 industrial establishments for which data were collected during the municipal interviews. Estimated pre-treatment costs are then compared to surcharge rates to determine if the ESSS charges actually provide an economic incentive to adopt pre-treatment by allowing establishments to lower overall costs when they pre-treat their waste water.

A generic approach has been used to estimate pre-treatment costs using published data on treatment system component cost curves (see Appendix D and E). Aggregate treatment system costs, depicted for one effluent flow condition in Figure 3.1 should be considered as order of magnitude estimates that are meaningful only in a statistical sense. The estimate for any particular establishment is likely to be inaccurate, but the averages across all establishments are nevertheless of interest.

The treatment costs of relevance in the pre-treatment decision are total rather than incremental costs over the establishment's planning horizon since it is assumed that establishments are considering a treatment/no-treatment decision as opposed to a decision to augment an existing pre-treatment system. Total estimated capital costs for the 28

FIGURE 3.1: TOTAL INDUSTRIAL PRE-TREATMENT COSTS



NOTE: BASED ON REGRESSION CURVE IN APPENDIX E

sample firms averaged $2.4M and ranged from $0.4M to $6.2M. Total annual operating and maintenance costs averaged $1.07M, ranging from $0.125M to $3.4M. (These values lie beyond the range depicted in Figure 3.1 because they represent effluent flow conditions not shown here.)

In contrast, reported annual surcharge payments by these firms averaged $74,400 and ranged from $15 to $372,700.. Surcharge costs therefore amounted to only 9% of estimated operating and maintenance costs on average, and at the maximum, were only 43% of estimated pre-treatment operating and maintenance costs.

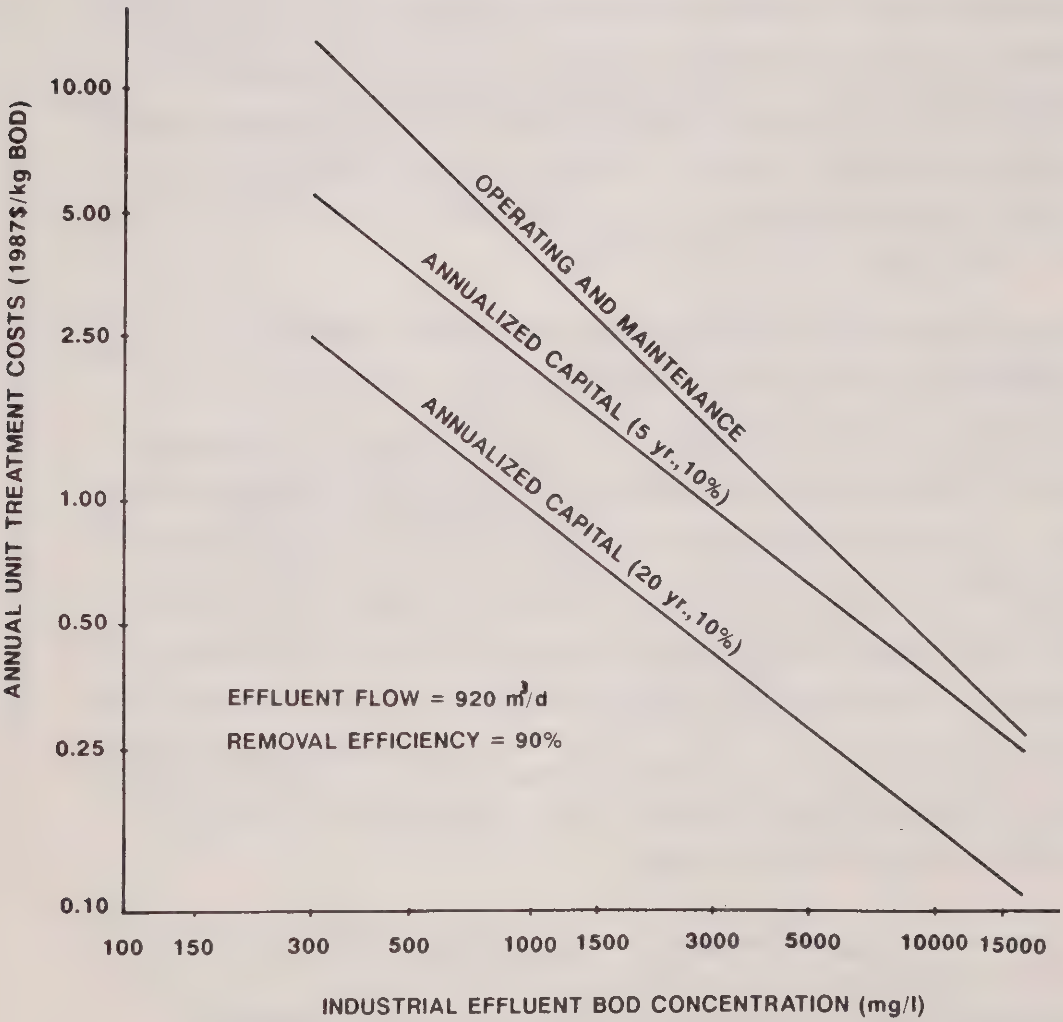
These numbers suggest that the option of paying a surcharge can be much less costly than installing pre-treatment. This conclusion was also supported in interviews with municipal staff who indicated that for 22 out of 29 case studies that were discussed, the decision to pay the surcharge was an economic decision.

A similar conclusion is obtained when comparing operating and maintenance costs to surcharge rate levels reported in the municipal survey. The average ESSS rate, expressed as dollars per kg BOD discharged, was $0.264 ranging from $0.032 to $0.770 (Table 2.7) while only four out of 24 of these reported ESSS rates for BOD exceed estimated unit operating and maintenance pre-treatment costs at the low end of the range in Figure 3.2. All of the reported ESSS rates exceed the estimated unit operating and maintenance costs for individual establishments discussed during municipal staff interviews; these ranged from $1.15 to $38.71 and averaged $8.02.

3.2 Municipal Treatment Costs

Municipal sewage treatment systems are designed to receive an influent flow exhibiting a much narrower range of variation in quality than is seen in industrial wastewater. The principal determinant of cost for secondary

FIGURE 3.2: AVERAGE COSTS FOR INDUSTRIAL PRE-TREATMENT



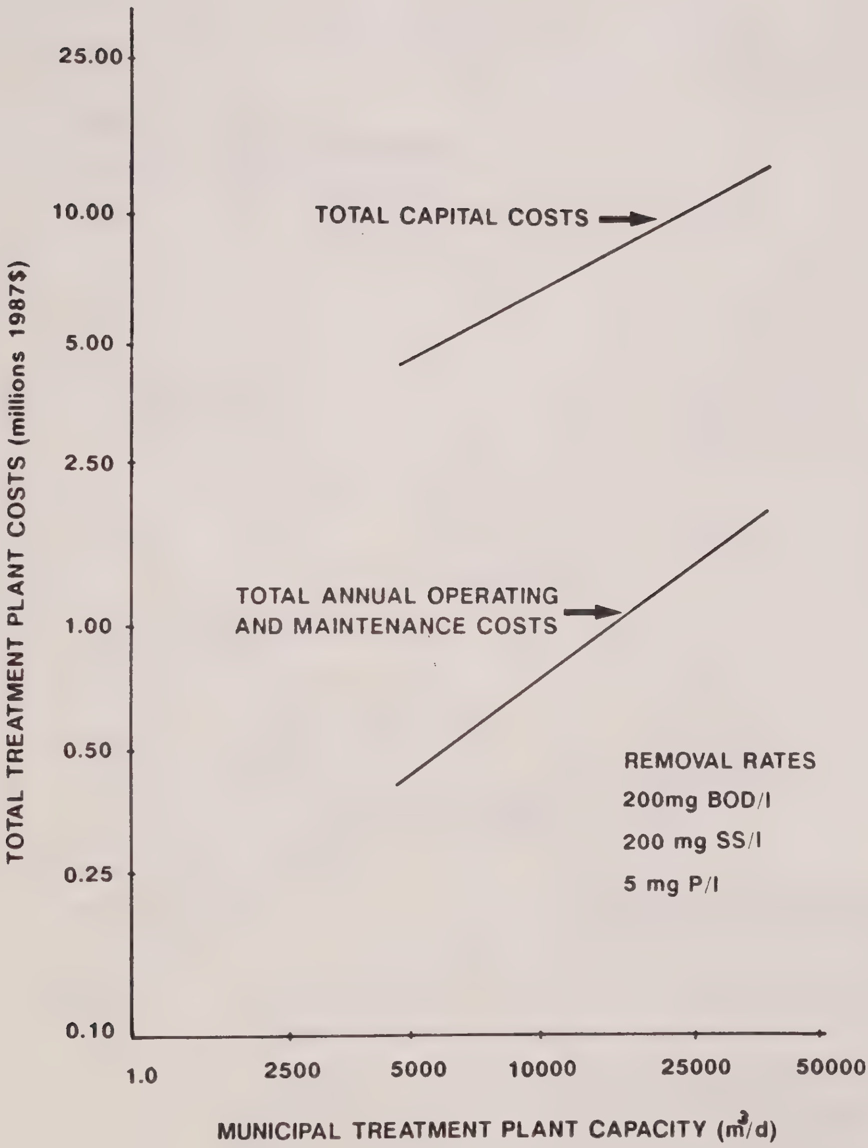
NOTE: BASED ON REGRESSION CURVE IN APPENDIX E

treatment systems is maximum expected influent volume which governs required plant capacity. Municipal treatment system costs based on capacity requirement are depicted in Figures 3.3 and 3.4. These costs are for conventional activated sludge systems with phosphorus removal and are extrapolated over the range of flows reported by municipalities with ESSS programs. Total annual costs are shown in Figure 3.3 while these are expressed as average values ($/kg BOD) in Figure 3.4. In Figure 3.4, capital costs are expressed in annual terms based on amortization over 20 years at a 10% rate of interest. Annualized average capital costs in Figure 3.4 vary from $0.058/kg BOD to $1.56/kg BOD and total annual costs vary from $1.31/kg BOD to $2.79/kg BOD.

Average costs for BOD, that incorporate assumptions regarding the apportionment of costs among chargeable parameters, are given in Table 3.1. The assumed apportionments of total costs to BOD are representative of apportionments used in deriving ESSS rate structures. Resulting costs compare favourably with the ESSS BOD rate levels in Table 2.7. For the 50% apportionment, average operating and maintenance costs at $0.25/kg BOD are essentially the same as the average ESSS BOD rate ($0.26). While there is considerable variation in ESSS rates, 20 out of 26 reported ESSS rates for BOD are in the $0.10 to $0.70/kg BOD range covered by average operating and maintenance costs that correspond to the 50% apportionment, while 14 out of 26 are in the corresponding range for total average costs (i.e. operating and maintenance plus capital/kg BOD). These comparisons suggest that ESSS charge rates for BOD approximate average municipal treatment costs.

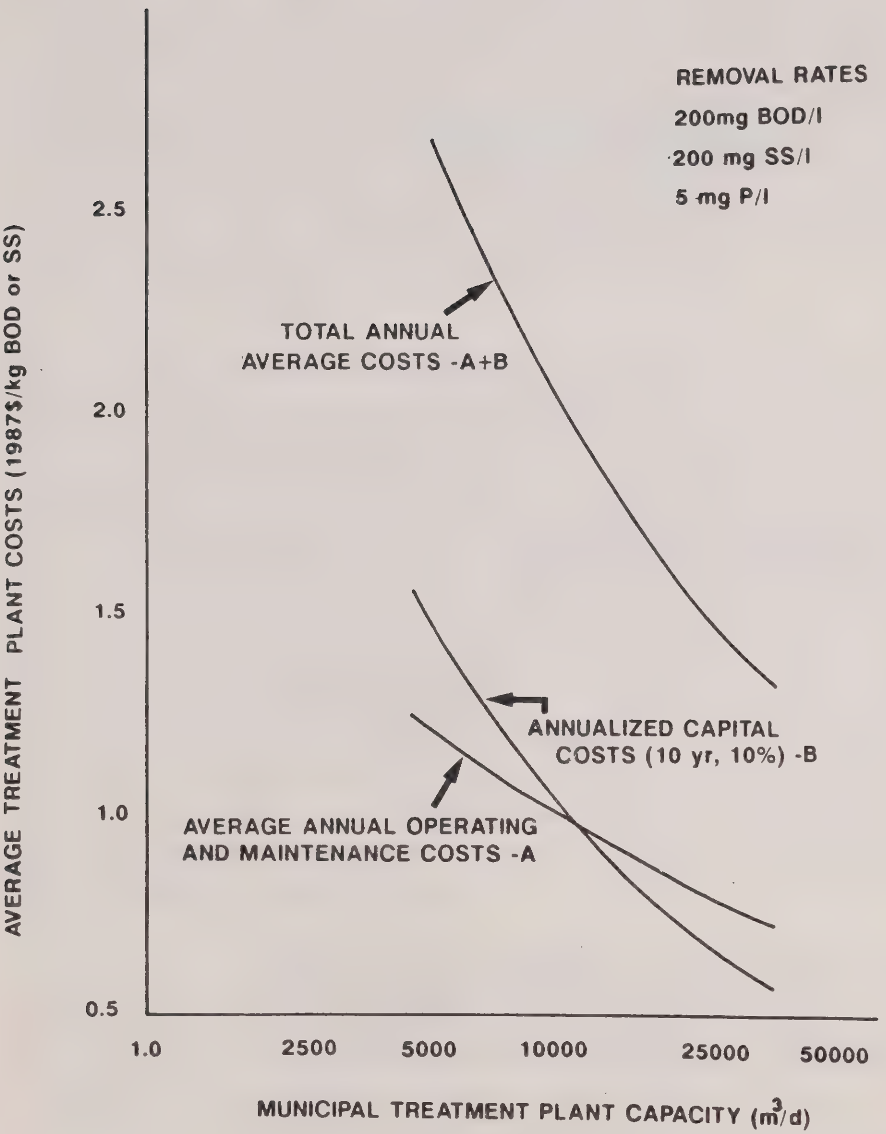
In comparison to industrial pre-treatment costs, municipal treatment costs, expressed on a average basis, are considerably lower. This is to be expected given the economies of scale inherent in the technologies assumed here for costing purposes. Based on these costs data, pre-treatment for conventional pollutants (i.e. BOD, SS) is in fact cost-

FIGURE 3.3: TOTAL MUNICIPAL SEWAGE TREATMENT COSTS



NOTE: BASED ON DATA IN APPENDIX D

FIGURE 3.4: AVERAGE MUNICIPAL SEWAGE TREATMENT COSTS



NOTE: BASED ON DATA IN APPENDIX D

TABLE 3.1

MUNICIPAL COSTS BOD REMOVAL IN MUNICIPALITIES WITH ESSS PROGRAMS

		Maximum Reported	Average	Minimum
		1987 $/kg BOD		
100% Apportionment[1] of Costs to BOD				
	O & M	1.60	0.49	0.29
	Capital	2.17	0.26	0.10
	Total	3.77	0.75	0.39
50% Apportionment[1] of Costs to BOD				
	O & M	0.80	0.25	0.15
	Capital	1.09	0.13	0.05
	Total	1.89	0.38	0.20
25% Apportionment[1] of Costs to BOD				
	O & M	0.40	0.12	0.07
	Capital	0.54	0.07	0.03
	Total	0.94	0.19	0.10
Reported ESSS Charge[2] Rates for BOD		0.77	0.26	0.032

Note: 1 Average costs are based on municipal treatment capacity flow figures provided in responses to the ESSS Municipal Survey. Cost figures are extrapolated from Appendix D data (see Appendix E). Maximum costs are based on a minimum reported flow of 1.9 m^3/d while average and minimum costs are based on average and maximum flows of 174.4 and 1515.1 m^3/d respectively.

2 ESSS charge rates for BOD are from Table 2.7 above.

effective only in situations where large establishments discharge effluents to small municipal facilities. We have seen that in such situations, direct negotiations between the discharger and the municipality regarding municipal cost recovery and pre-treatment usually take place (Section 2.9). The data do not however support a similar conclusion with regards to other contaminants such as metals and toxic organic compounds which may not be amenable to removal by conventional municipal treatment systems.

3.3 Economic Efficiency

Brief mention is made in section 2.4 above of the concept of economic efficiency. In that section, the concept of economic efficiency is interpreted narrowly in terms of achieving a least cost or "cost effective" combination of industrial pre-treatment and municipal treatment in order to attain a given level of final effluent quality.

The conventional interpretation of economic efficiency by economists is broader than this. It encompasses the benefits of water quality protection in bodies of water receiving treated wastewater as well as the above-mentioned costs of treatment. Economic efficiency in this broader context requires that wastewater treatment be provided up to a level at which the value of resulting water quality benefits are judged to be commensurate with the extra costs. These benefits may be non-economic in nature (i.e. recreation, enhanced ecosystem values) as well as economic (fishery benefits, drinking water treatment cost reductions, etc). However, benefits of water quality improvements are not directly relevant to the discussion in this report in that the focus here is on the use of the ESSS within municipal jurisdictions. Municipalities are not in a position to address the larger question of how to strike an appropriate

balance between wastewater treatment costs and the associated water quality benefits since water quality and effluent objectives are determined by the Province. The municipality's role is, therefore, to achieve mandated water quality and effluent objectives in a cost effective manner.

To the extent that the ESSS is effective in achieving water quality goals and objectives, there should be an interest at the Provincial level in its implementation. None the less, the municipality is responsible for implementation; and from a municipal perspective, cost effectiveness rather than a balancing of incremental costs and benefits will be the primary emphasis for decision making about ESSS charges.

3.4 Marginal Costs

Marginal costs are defined by economists as the incremental costs of production that are caused by incremental changes in the level of production activity. For sewage treatment, marginal costs could be measured as those changes in operating an capital costs that occur in conjunction with:

- increases over time in wastewater flows to a treatment plant,
- increased pollutant loading for a given flow and final effluent quality,
- efforts to improve effluent quality from the municipal treatment plant for a given level of influent flow and quality.

Marginal costs are of interest in this study because they provide an economic basis for setting ESSS charge rates that will promote economic efficiency. An example based on phosphorus removal from wastewater can illustrate this. The extra costs faced by a municipality that installs a phosphorus removal system at a treatment facility are estimated to be in

the range of \$3 to \$10/kg P removed (Appendix D, Table D.4). This is the marginal cost of enhanced phosphorus removal. Consider an ESSS charge for phosphorus set equal to this cost. Any industrial sewer user who wishes to minimize costs will choose to pay the surcharge if pre-treatment costs per kg P exceed the ESSS charge; otherwise pre-treatment will be adopted. Phosphorus removal will then be achieved using the least-cost method whether that be by pre-treatment at source or by treatment at the municipal plant.

The rate setting recommendation that follows from economic theory is that rates should be based on the marginal cost of providing a service. In certain cases, such as the phosphorus removal case above, marginal costs are readily estimated. Other examples include:

- a charge on an industrial effluent's excess chlorine demand set equal to the additional chlorine required for disinfection (Olliffe, 1963)
- a charge on metals in effluent that is set to recoup the additional costs of landfilling or incinerating a sludge that are incurred because the sludge cannot be applied to crop land due to its high metal content (Ingold and Stonebridge, 1987).
- a charge on grease emissions set to recoup the cost of cleaning grease accumulations in the collectors.

In the case of BOD, SS and flow, however, marginal costs are not readily estimated. Treatment system costs cannot be unambiguously apportioned between BOD and SS since both of these are simultaneously removed from wastewater by the same treatment processes (see section 2.11).

Wastewater flows typically exhibit wide variation within the day and throughout the year while average influent BOD and SS concentrations are much less variable. Treatment systems must be designed to accommodate

peak wastewater flows and produce an acceptable effluent quality under varying flow conditions. The nature of treatment system processes, the close link among BOD, SS and flow and the relatively narrow range of average BOD and SS concentrations all contribute to a treatment system design process that is based largely on wastewater flow volume.

Once a treatment plant is in place, the costs of operating the plant will depend primarily on flow. Given the resilience that is built into treatment systems to accommodate peak flows, typical variations in wastewater inflow strength over a given year which are within the treatment system design specifications will have a negligible impact on operating costs. The marginal costs of incremental changes in BOD or SS loading to the treatment plant are, therefore, negligible in the short-run.

However, if a community grows, the ability of the treatment system to accommodate peak wastewater flow conditions is strained, and effluent quality deteriorates. This in turn motivates planning for expansion of the treatment plant. The costs associated with growth of wastewater flow and BOD and SS loads are the costs associated with this new capacity. In the long run, marginal costs are not negligible, but rather are the extra costs of adding and operating new capacity to a treatment facility.

Regardless, of whether or not marginal costs can be readily estimated, the feasibility of using marginal costs to set rates will depend on non-economic constraints that also bear on the rate setting exercise. Among these are:

- municipal cost recovery requirements,
- making the rate setting procedure compatible with municipal financial systems,
- maintenance of relatively stable sewer user rates over time to facilitate municipal and industrial planning,

- establishing rates that can be understood, revised and updated by municipal staff,
- establishing rates that can be understood by the industrial sewer user in a way that enables the user to respond by making economically efficient pre-treatment decisions,
- establishing rates that are seen to be legitimate by the majority of sewer-users.

Given these constraints, it is often preferable to have a simple rate setting procedure based on average rather than marginal costs. Average cost calculations may provide reasonable estimates of marginal cost if total costs over the long run increase at a uniform rate in response to long run increases in wastewater discharges. That is, if average costs per kg of BOD or SS removed from the wastestream are constant, then average costs are equal to marginal costs.

Whether average costs or marginal costs are used to set ESSS rates, it is necessary that they be measured using both operating costs and capital costs. This means that during the period over which treatment system capacity is deemed adequate to handle incoming peak wastewater flow volumes, the capital cost that is factored into the rate setting exercise should include depreciation costs evaluated at replacement value as well as interest and other financing costs. When the level of treatment system capacity utilization approaches the design limit and effluent quality is impaired, then the capital costs of capacity expansion should be used to set ESSS rates. By the time that the treatment system capacity expansion costs are incurred, the sewer use rates should fully reflect these capital costs for expansion.

Up to this point, only direct costs for treatment have been considered. In addition to these, there may be costs associated with the detrimental impacts of poor effluent quality on receiving waters. Environmental damages caused by pollutants are borne by downstream water users, by the

public at large and by the natural ecosystem. While such damages may be quantifiable, they do not represent the municipal cost of removing a pollutant prior to release of wastewater into the environment. However, recovery, through the ESSS, of indirect costs from sewer-users responsible for discharging the offending contaminants can be justified on the basis of:

- providing an economic incentive to reduce the contaminant discharge,
- collecting compensation for affected downstream water users, or
- financing remedial measures to counteract deleterious impacts of the contaminant release.

If any of these justifications are used for setting an ESSS charge the role of the ESSS is pushed beyond that of direct cost recovery. This would not be a significant departure from existing practice since survey results show that ESSS programs are already used by municipalities to penalize dischargers and induce pre-treatment (section 2.4). However, there are no clear guidelines for introducing factors such as compensation or ecosystem rehabilitation into ESSS rates.

The introduction of ESSS rates that do not have a clear link to treatment system costs will likely be resisted by affected dischargers. This resistance can undermine a municipalities sewer use program if it creates opposition that acts to impede program implementation. Of course, if environmental damages which are hitherto overlooked in sewer use charges become direct costs for the sewage authority by virtue of fines, penalties, monitoring fees and other costs imposed by the Province on the municipality in response to the discharge of contaminants to a receiving water, then the municipality is given a clear financial incentive to pass these extra costs to sewer users through an ESSS.

4.0 ADVANTAGES & DISADVANTAGES OF THE EXTRA-STRENGTH SEWER SURCHARGE

4.1 Industrial Pre-treatment

Respondents in the nation-wide municipal survey cited the inducement of industrial pre-treatment as a principal objective of ESSS programs. Data from both this survey and the subsequent municipal interviews suggested that their objective was realized to a degree.

A summary of responses from the municipal survey (Table 4.1) suggests that by far the most common industrial response to ESSS is to improve housekeeping practices. Beyond this the most common responses are to study the means of reducing the surcharge cost, to install pre-treatment, to change production processes and to analyze waste flows to verify the surcharge charge level.

Forty-one percent of the firms being monitored took some sort of action, while 19% went as far as installing pre-treatment. Eight of the 31 firms discussed during the municipal interviews had also installed pre-treatment. These data suggest that the ESSS can be an effective means of promoting pre-treatment. How then to reconcile this finding with the finding of the previous chapter that ESSS rates are probably too low to induce pre-treatment on strictly economic grounds.

The answer likely relates to both the kind of the pre-treatment in use and to the nature of the surcharge program. In this report, we consider treatment technologies such as neutralization, anaerobic reactors, sequencing batch reactors and activated sludge systems (see Appendix D). In practical applications there may be less costly options, examples of which are the diversion and recovery of blood in slaughterhouses, the use

TABLE 4.1

RESPONSE OF INDUSTRY TO SURCHARGE PROGRAM

	ONTARIO	PRAIRIES	OTHER	CANADA
Total Number of Firms Taking the Following Types of Action:				
Conducted studies to reduce surcharge cost	68	19	3	90
Changed raw material inputs	11	3	1	15
Changed production processes	56	4	3	63
Used more water to dilute waste flows	3	20	0	23
Analyzed discharge to verify charge levels	43	25	1	69
Recovered waste products for reuse or resale	37	8	1	46
Installed pre-treatment systems	45	19	11	75
Used less water	25	2	1	28
Improved housekeeping practices	101	65	4	170
Other	0	2	0	2
Total Number of Firms Taking Positive Action of Any Type:	83	60	19	162
Total Number of Firms Being Monitored	256	121	23	400
Total Number of Firms Paying a Surcharge	233	91	23	347

Source: Extra Strength Sewer Surcharge Municipal Survey

of traps to control grease and oil discharges or various other recovery/reuse systems. Technologies of this sort may even provide an economic return if recovered products have a market or production value (recovered slaughterhouse wastes may for instance have market value as a protein feed stock).

Even if pre-treatment costs exceed ESSS charges, firms may still select pre-treatment given non-financial considerations. For example, from a technical stand point, factors such as available inhouse expertise or space constraints may preclude pre-treatment as a viable option. The regulatory environment within which the ESSS is placed may also provide the extra non-economic incentive to induce pre-treatment. For example, one case discussed during the municipal staff interviews involved a firm that applied for entry into the ESSS program in order to become eligible for a discharge permit for its effluent. Pre-treatment requirements were imposed at that time on the firm.

The promotion of pre-treatment is, therefore, a distinct advantage of ESSS programs, though the extent of pre-treatment will depend on the overall regulatory framework. Even without adoption of pre-treatment, ESSS charges can at least increase awareness among industry representatives of municipal costs for treatment of high strength industrial wastewater.

4.2 Municipal Impact of the ESSS

At the municipal level, potential impacts of the ESSS could entail impacts in the collection and treatment system or impacts on the level of bylaw enforcement activity.

Noticeable treatment plant effects were reported in the municipal survey by 19 out of 29 municipalities with ESSS programs (Table 4.2). Principal

TABLE 4.2

SURCHARGE PROGRAM IMPACTS AT MUNICIPAL TREATMENT PLANTS

JURISDICTION	ONTARIO	PRAIRIES	OTHER	CANADA
Number of Municipalities Reporting the Following Impacts:				
No changes detected	6	3	1	10
Reduced hydraulic loading	5	3	0	8
Increased hydraulic loading	0	0	0	0
Reduced loading of BOD	6	6	1	13
Reduced loading of SS	6	5	1	12
Reduction of operating costs	3	1	1	5
Reduction of capacity requirements	1	1	0	2
Delay of planned capacity expansion	1	2	0	3
Reduced loading of other contaminants	1	5	0	6
Other	0	2	1	3
Total Number of Respondents	13	13	3	29

Source: Extra Strength Sewer Surcharge Municipal Survey

among the cited effects were reductions in BOD and SS loadings and reduced effluent flows. Economic effects were also reported; five respondents indicated a reduction of operating costs and five reported capacity utilization effects.

The case for impacts on bylaw enforcement activity is not as clear cut. Survey data suggest that municipalities with ESSS programs report a greater incidence of problems with industrial discharges and greater number of bylaw violation and prosecutions.

At the same time, however, these municipalities tend to be larger and have more industrial clients. The more severe nature of problems in communities with ESSS programs may reflect their larger size and may well explain why ESSS programs were, in fact, implemented.

To discern if there are any measurable impacts of ESSS programs on bylaw enforcement activity, a statistical analysis was undertaken (Appendix E). Regression techniques were used to differentiate between the effects of municipality size and ESSS program activity on the frequency of bylaw violation. It was expected that the frequency of violations would increase with community size (or the number of industrial accounts) simply because there are more dischargers; while the presence of an ESSS program should reduce the frequency of violation. The statistical analysis suggests that community size and the total number of industrial accounts are in fact the main factors affecting the incidence of bylaw violations. ESSS programs appeared to depress the incidence of violations as would be expected but the relationship was not statistically significant. A similar analysis of the incidence of wastewater collection and treatment system problems associated with industrial discharges was inconclusive.

At the municipal level, therefore, beneficial treatment plant effects are reported by survey respondents but statistical evidence of a beneficial impact was inconclusive.

4.3 Program Costs and Revenues

From an economic and a municipal accounting perspective, a basic requirement of ESSS programs is that ESSS revenues at least cover program related costs.

Survey data on revenue generation are reported in Table 4.3. Total ESSS revenues collected by municipalities responding to revenue questions in the survey were $9.1 M while the average revenue collected was $380,000 (24 responses).

ESSS program costs were not obtained directly from respondents. They can however be estimated from program activity levels. An average of 4.3 municipal staff years were dedicated to ESSS program activities by 18 respondents, in addition, an average of 260 samples were analyzed for each ESSS program (23 respondents). If we assume a staff salary level of $30,000 and a sample analysis cost of $80 (based on commercial rates for BOD, SS, grease and pH), the survey data would imply a direct program cost of about $150,000. This compares favourably with the average ESSS revenue of $380,000.

Average sewage system operating and maintenance costs per municipality in 1986 incurred by municipalities with ESSS programs were:

collection - $1.77 M (23 respondents)
treatment - $2.75 M (28 respondents)
total - $4.40 M (28 respondents)

ESSS program revenues reported above made up about 9% of there reported total costs or 14% of treatment costs. Revenue generation is therefore not a trivial aspect of ESSS programs. The scope of the present study did not, however, permit an analysis of surcharge revenues relative to system costs that can be attributed to extra-strength waste.

TABLE 4.3

SURCHARGE PROGRAM REVENUES IN 1986

JURISDICTION	ONTARIO	PRAIRIES	CANADA
Total Revenues Collected by Respondents	$7,632,400	$1,333,300	$9,063,700
Total Annual Surcharge Revenues Collected by Each Municipality			
Average	$ 508,828	$ 190,475	$ 377,656
Maximum	$2,704,547	$ 720,000	$2,704,547
Minimum	$ 2,800	$ 7,500	$ 2,800
Total Number Responding	15	7	24
Average Annual Revenue Per Firm Being Charged	$ 38,143	$ 12,265	$ 33,215

Source: Extra Strength Sewer Surcharge Municipal Survey

4.4 Cost Allocation Effects

An equitable allocation of treatment system costs was identified as an important objective of implemented ESSS programs (see section 2.2). Cost allocation among users cannot be explicitly addressed with primary data in this study; however, it has been the focus of attention in other ESSS studies.

Johnson (1969) undertook a hypothetical evaluation of the cost burden of 10 alternative sewer rate structures including quality based structures using detailed customer account data from a large eastern U.S. city. The residential cost share varied from 33% (straight BOD charge) to 94% (flat fee) while the industrial share varied from 1% (flat fee) to 51% (straight BOD charge). The food and chemical sectors bore the largest share within industry under the water volume and BOD charge schemes.

Johnson used the following criteria to evaluate these charge schemes:

1. equity based on the cost of treatment services received
   - user charge should match the cost of effluent treatment for each user

2. equity based on ability to pay
   - user charge should be proportional to income of the user or should increase progressively as income increases

3. resource allocation
   - unit price for sewage services should equal marginal treatment costs

4. administration
   - charge scheme should be easy to administer

5. revenue generation
   - revenue should increase as costs increase and user population grows

Overall the BOD charge schemes rated high in terms of equity based on the cost of treatment services received, resource allocation and revenue obtained but low in terms of ease of administration and equity based on ability-to-pay. The flat fee was deemed easiest to administer and the property tax scheme was considered most equitable from the perspective of ability-to-pay.

Kaemer and Glascow (1979) evaluated the cost burden of a property tax based charge scheme in Los Angeles prior to implementation of an ESSS. They found that industry generated 35% of waste flows but paid only 11% of tax revenues.

Provided that surcharge rates are determined by means of a careful evaluation of treatment system costs, in particular of marginal costs; and that discharge sampling provides a sufficiently accurate estimate of industrial waste strength, equitable cost allocation is a major advantage of an ESSS program.

4.5 Administration and Implementation

To this point in chapter 4.0, only beneficial program effects have been discussed. ESSS program disadvantages arise from implementation and administrative difficulties.

Industrial opposition to surcharge programs can range from complaints to more formal court or other action (Table 4.4). The most frequent type of opposition involved complaints about ESSS programs and particularly about program fairness. More substantial action such as court challenges and requests for rate reviews were rarely encountered. However, 10 out of 29 respondents had encountered refusals on the part of industry to pay the surcharge.

Apart from the conflict that an ESSS program may create with industrial clients, institution of an ESSS requires a significant departure from customary billing practices. It may mean establishing a distinct office for industrial billings and can entail an extra burden on staff and other resources. While this new activity increases the size of the municipal bureaucracy, it should not result in any extra cost burden since the program rate levels can be set to recover program costs.

TABLE 4.4

INDUSTRY OPPOSITION TO THE SURCHARGE PROGRAM

JURISDICTION	ONTARIO	PRAIRIES	OTHER	CANADA
Average Frequency Rating for Cases of Industrial Opposition				
(1=never occurred; 2=infrequent; 3=frequent occurrence)				
(A) Complaints				
- cost too high	2.1	2.0	1.7	2.0
- charge scheme too complex	1.7	1.6	1.0	1.6
- charge unfair	2.2	2.0	1.7	2.0
- monitoring is a nuisance	1.8	1.9	1.7	1.8
(B) Court challenges	1.1	1.0	1.0	1.0
(C) Request for formal review	1.0	1.2	1.0	1.0
(D) Refusal to pay	1.3	1.4	1.3	1.3
Total Number of Respondents	15	13	3	31

Source: Extra Strength Sewer Surcharge Municipal Survey

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Why Use an Extra Strength Sewer Surcharge?

The strongest argument in support of the ESSS is the fair allocation of costs. Industry with high strength waste places a disproportionate burden on sewage treatment facilities that must be reflected in the charge levied back to industry in order:

- to prevent subsidization of high-strength waste discharges by other industrial, commercial and residential users, and

- to convey to industry an accurate assessment of the cost of their discharge practices and to then promote efficient decisions on industry's part regarding pre-treatment.

A well designed ESSS program will promote pre-treatment wherever it is economically advantageous to pre-treat rather than treat at a central facility. Where pre-treatment is not adopted, users will pay for services in proportion to the cost burden they impose on the municipal sewage system; this result ensures equity in the sense of payment in proportion to benefit received.

5.2 Who Should Use the Extra Strength Sewer Surcharge?

Existing ESSS users tend to be larger, more heavily industrialized municipalities. They have a greater incidence of industrial problems and consequently have mounted more sophisticated regulatory programs.

The decision to adopt the ESSS should be left to municipal sewerage authorities. They are, after all, best acquainted with their own

dischargers and are likely in the best position to evaluate the kind of regulatory and cost recovery mechanisms that will best serve their needs. Decisions regarding the ESSS should however be well informed decisions. To this end, many municipalities will benefit from assistance in the form of model bylaw provisions for an ESSS and guidelines regarding rate setting and program structure.

Any municipality with significant high strength loadings from industrial establishments are obvious candidates for adoption of an ESSS program. However, they can anticipate considerable opposition to such a program. Smaller municipalities with one or two high strength waste dischargers generally should opt for direct negotiations with dischargers over cost sharing rather than go to an ESSS rate structure.

5.3 What Type of Program?

The guiding principal in program design should be simplicity and ease of implementation.

Eligibility for inclusion in the program must be broad enough to capture any significant discharges, eligibility should not therefore be limited to certain sectors. On the other hand, monitoring and imposition of a surcharge should be limited to significant dischargers, who, taken as a group, will have a demonstrable impact on sewage treatment.

A very broad coverage can be achieved if users are classified by industrial sector and a representative waste strength assumed for each sector. This increases the scope and revenue generation potential of the program considerably. However, unless the municipal authority is willing to mount a monitoring program to verify waste strengths in response to challenges, then the objective of equity can be jeopardized.

In terms of waste characterization in the surcharge formula, standard parameters to be included are BOD, SS and, grease and oil. Certain municipalities use COD in place of BOD.

The use of other parameters must be based on local conditions. Generally, however, the ESSS should focus on conventional parameters rather than toxics or any contaminants that are prohibited from effluent or sludge streams. Such contaminants should be included in an ESSS program only when incremental municipal costs associated with their discharge in wastewater can be clearly identified. By linking ESSS charges in an unambiguous manner to treatment costs, the ESSS is more likely to be viewed as a fee for service and to be accepted by industry.

A key feature of any ESSS program will be the associated effluent monitoring activity. The norm is to use composite samples and to sample each firm on a weekly to monthly basis. However recent statistical work on sampling frequency for ESSS programs (Hulme, Johnson, Walker and Ellis, 1985) suggests that a uniformly accurate assessment of waste strength across establishments requires sampling frequencies to vary across establishments in proportion to the variability of their discharge flow and concentration. Sampling programs should therefore be sufficiently flexible to allow for different sampling schedules across establishments in order to assure greater accuracy and by implication greater equity in surcharge assessments.

5.4 What Type of Rate Structure?

While there appears to be considerable variation in rate structure from one bylaw document to another, most of the rate structures in use can be expressed as relatively straight forward relationship involving discharge volume, a base rate applied to volume, and a factor estimated from waste strength to adjust the base rate upwards.

Salient features that differentiate the more frequently encountered rate structures are:

- whether the charge applies to the entire pollutant load or to a measure of excess load, and

- the manner in which multiple parameters such as BOD and SS are combined (either as a linear combination or as the maximum value of rate factors derived for each parameter).

Ideally, the charge should be levied on the entire load rather than just an excess load measured by reference to a threshold concentration value. This will eliminate perverse incentives to dilute effluent with clean water in order to reduce concentration below the threshold. The practice of intentionally diluting wastewater discharges is discussed in the literature (Sims, 1979) and was reported by a few respondents to the municipal survey.

The question regarding how to combine parameters within the rate formula concerns in effect the problem of how to allocate the cost of treatment system components that remove multiple pollutants simultaneously. There are various philosophies and approaches to this issue that cannot be addressed here. The simplest rate formula is one that uses the maximum value approach, rather than weighting and combining concentration data. It may be preferred on this basis, though a more detailed investigation of the rate structure question in consultation with representatives of municipal sewage authority staff is warranted before any recommendation can be made.

5.5 <u>What Rate Level</u>?

The rate level must be based on treatment system costs to be economically meaningful and to assure equity. All costs that are affected by high strength waste should be accounted for including operating, maintenance and capital costs.

Ideally costs will be calculated using incremental or marginal rather than average cost concepts. To be feasible, however, this approach must be interpreted in terms that are relevant to the municipal works department and to the municipal accountant.

In developing practical rate setting guidelines, consideration must be given to standard methods in use now. Beyond this, insights into the applicability of marginal cost pricing may be gleaned from the literature on pricing practices in the private sector and by detailed case study investigations of sewage authority financing.

5.6 How to Introduce an ESSS Program?

Program implementation is a critical step in developing a successful ESSS program. The implementation period should involve some municipal interaction with industrial establishments in order to explain the purpose of the program and to provide an opportunity for feedback from the affected users. A period of grace of about 12 months, during which decisions regarding pre-treatment can be implemented, is often provided.

At the same time, however, municipal officials should be very purposeful in their intent to implement a program and to levy charges on industry that are an accurate reflection of treatment costs. In particular, all cost components (i.e. capital as well as operating and maintenance) should be accounted for in the surcharge rate setting exercise from the outset to prevent difficult readjustments once a program is in place. In the event that new ESSS charges pose a significant and unexpected cost increase for certain clients, it may be necessary to phase in the charges over a 2 to 3 year period to maintain some rate continuity through time. Once ESSS rates are fully established, they should be changed only in response to changing system costs.

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APPENDIX A

ANNOTATED BIBLIOGRAPHY ON THE EXTRA-STRENGTH SEWER SURCHARGE

INTRODUCTION

A brief review of literature on the use of an extra-strength sewer surcharge is presented below. The review extends to literature on the broader topic of the sewer service charge of which the surcharge is one formulation, but it does not cover the general topic of effluent charges for pollution control.

Citations are arranged alphabetically, based on author name. Key words identify the main subject category of each reference; these key words and the numbers of associated references are provided in Table A.1.

Additional references that could not be secured and reviewed within the scope of this study are listed at the end.

TABLE A.1

SUMMARY OF REVIEWED LITERATURE

Key Words	Document Page No.'s	Comment
Case Study	4, 5, 25, 31, 32, 36, 44	describes particular municipal experience
Case Study (Canada)	8, 13, 33	as above for Canadian municipality
Cost Allocation	12, 22, 26	provides information on cost burden by user class
Discharge Sampling	19, 21	
Economic Efficiency	11, 38, 39, 42	assess impact of charge structure on overall cost of treatment
Equity	12, 22, 25	relates cost burden by user class to benefits received in terms of
treatment		
Firm Response	11, 16, 38	describes how firms respond to a surcharge
General	9, 10, 24, 30	review of practices in France, Germany, and other nations
Program Evaluation	14, 16	broad discussion of surcharge program costs, impacts, etc.
Rate Structure	6, 12, 19, 21, 28, 29, 34, 35, 37, 41, 43, 44	contains information on rate formulas or charge levels
Treatment Costs	4, 28, 35, 44	describes how treatment costs enter into rate level calculation
U.K. Practice	14, 19, 37	review of surcharging practice in U.K.
U.S. Practice	16, 26, 29, 34, 40, 41	review of surcharging practice in U.S.

NOTE: Page numbers are for this appendix and commence with "A-"

REVIEW ABSTRACTS

Anderson, N.E. and B. Sosewitz. 1971. "Chicago Industrial Waste surcharge Ordinance." Journal of the Water Pollution Control Federation 43(8):1591-1599.

This paper reviews the 1970 Surcharge ordinance for the Metropolitan Sanitary District of Greater Chicago. Key features of the ordinance include:

- an exemption for all industries discharging less than 10,000 gpd to avoid unjustifiable administrative and user cost burdens;

- a charge rate based on volume, BOD and SS with no threshold quality values;

- a deductible allowance per employee for sanitary wastes

- deduction of taxes paid to the sanitary district from the gross surcharge cost to get net cost payable;

- self monitoring by industry to reduce municipal administrative costs and to keep industry aware of their waste discharges;

Calculations for unit charge rates account for operating, maintenance and depreciation costs. Costs are allocated as follows:

1. Volume - conveyance of wastes, pumping stations, grit chamber, primary and final settling tanks;

2. BOD - aeration tanks, blower house;

3. SS - sludge disposal

Anonymous. 1971. "Cities Treat Industrial Process Waste." Environmental Science and Technology 5(10):1000-1002.

Sewer surcharge programs in New York and Chicago are reviewed. These and other surcharge programs have been introduced largely as a result of Federal incentives under its sewerage grant programs.

The New York ordinance prescribes acceptable waste quality and stipulates a surcharge based on BOD and SS discharges in excess of 300 mg/l and 350 mg/l respectively. The "normal" allowances are set at twice domestic levels. The charge is based on total water consumption less estimated loss or retention in the product and on typical concentrations by SIC category.

Chicago uses a surcharge in which the normal allowance is based on volume regardless of strength. The exemption level, 10,000 gpd, entails a gross revenue loss of \$200-\$300/year (\$1970 U.S.) per discharger and in total amounts to 5% of total collected surcharge revenues. The Chicago program requires self-monitoring with verification by the sewerage agency.

Boisselle, E.B. and P. Côté. 1982. "A Method for Wastewater Treatment System User Cost Allocation, Volume 1." Report No. EPS 3-WP-80-6E, Environment Canada.

This report documents the technical background, development and testing of a computer model designed to allocate wastewater treatment system costs to beneficiaries. In a background discussion, user charges are identified as a requirement of certain capital grant programs and as a means of achieving an equitable distribution of system costs. Charging schemes in nine Canadian cities are reviewed. The majority of these use a standard extra-strength formulation of the charge but Lethbridge and Red Deer in Alberta apply a flat unit rate to industrial discharges of BOD and SS (i.e. no threshold).

The procedure for cost allocation put forward in this study identifies 12 categories for cost allocation. These correspond to current and future discharges of effluent and to property within the sewershed. Costs are allocated to effluents on the basis of volume, BOD (or COD), SS and a fourth parameter that the user can stipulate. Costs allocated to property reflect cost impacts of stormwater drainage through combined sewers (based on drainage area) as well as other costs not directly attributable to use. Flow sources corresponding to the 12 cost allocation categories are domestic, industrial, infiltration, public use and runoff.

Cost allocation assumptions are built into the model based largely on a consideration of design parameters. The user is required to input certain cost allocation assumptions and can alter others that are assigned default values.

Data input requirements are extensive. For the overall system these include interceptor and treatment plant design, average and peak flows by source, cost allocation data, influent quality data, numbers of small customers (domestic, commercial) and average loadings from these. For industrial customers, the user must input land valuation data, property

size (contributing area), effluent characteristics, type of sewer connection and reserved future flow. Additional information is required for each category of rate payer.

The model has a capacity to iterate the cost allocation exercise with alternative assumptions in order to evaluate the sensitivity of results.

Bubbis, N.S. 1963. "Industrial Waste Control in Metropolitan Winnipeg." Journal of the Water Pollution Control Federation 35(11):1403-1413.

This paper recounts the history of industrial waste control in Winnipeg and reviews the process of implementing a surcharge in the late 1950's.

After reviewing alternative rate structure formulations, the sewerage agency opted for the surcharge formula with normal strength assigned to BOD and SS. A key aspect of implementation was communication of the nature and purpose of the program to industry by dealing in turn with firms in each major industrial sector in the city.

Results of the program include reductions in waste volumes and loadings particularly from larger dischargers. Smaller firms typically preferred to pay the surcharge.

Committee on Water Problems. 1976. "Principles and Methods for the Provision of Economic Incentives in Water Supply and Wastewater Disposal Systems." Economic Commission for Europe, United Nations, N.Y.

This report provides an international review of the use of economic incentives in water resources management. Charges associated with discharge of effluents to city sewers are noted to be typically imposed in the first developmental stage of water resources management when demands do not exceed supplies. Other types of economic incentives such as abstraction charges are encountered later in the development process as supplies become fully utilized, serious impairment problems arise, large integrated management systems develop and water resource disruptions increasingly pose high costs on society. A consistent economic approach to water resources management was found to be fostered by legislation of a Water Act at senior levels of government.

Charges to cover sewerage services are noted to be used in Austria, parts of the USSR, Canada, Czeckoslovakia, Finland, the German Democratic Republic, the Federal Republic of Germany and the United States. Information on the form of the sewer charge is incomplete. The use of the extra-strength surcharge is noted only for Canada.

Despax, M. and W. Coulet. 1982. "The Law and Practice Relating to Pollution Control in France." 2nd ed. Commission of European Communities, Luxembourg.

This report provides a comprehensive review of the legal and institutional framework related to pollution control in France. Sewerage is provided by municipal authorities (communes) who are vested with the power to control industrial discharges to sewers. Any non-domestic discharge must be authorized by the municipality which can impose requirements for pretreatment. The applicant for an authorization can be required to defray capital and operating costs of the sewerage resulting from their discharge. The sewers need not be equipped with a treatment plant.

The municipality does not operate under a general obligation to treat industrial wastes, and industry can opt to seek authorization for direct discharge to a watercourse. Connection of industries to municipal sewerage in specific cases can however be required by federal decree.

Ethbridge, D. 1979. "User Charges as a Means for Pollution Control: The Case of Sewer Surcharges." The Bell Journal of Economics and Management Science." 3(1):346-354.

Synthetic and regression techniques are used to investigate the response of firms to the extra-strength sewer surcharge. Based on an assumed expediential functional form for the marginal cost of in-plant BOD removal and a mass balance equation for total BOD generated, the authors derive demand expressions for municipal treatment as a function of the surcharge.

Using the model, demand elasticities are derived for the beet sugar industry using parameters from a published cost curve. For a surcharge of $.0025/lb BOD, these are -6.5 and -0.3 for the treatment of excess BOD discharges and total BOD discharges respectively.

Cross-sectional BOD discharge data for poultry processors is then analyzed using regression techniques to estimate demand curve parameters for this industry. The following elasticities obtain for a surcharge of $.02/lb BOD:

- the surcharge elasticities of demand for treatment of total and excess BOD discharge per 1000 birds processed are -0.5 and -0.6 respectively
- the surcharge elasticity of demand for water used per 1000 birds is -0.4
- the total price elasticity of demand for water is -0.6

These results imply that imposition of a BOD surcharge of $0.02/lb would reduce BOD loadings by 75% for beet processing plants and by 25% for poultry processors.

Foess, G.W. and M.D. Mynhier. 1983. "Experiences with User Charge Litigation" presented at the 56th Annual Conference of the Water pollution Control Federation, Atlanta, Georgia, October 2-6.

A number of user charge issues raised in user charge litigation are reviewed; relevant to the extra strength sewer surcharge are the following:

Allocation of Costs to Wastewater Charge Parameters - components costs may be allocated based on function or design. The basis in use has a significant impact on the resulting rate level related to waste strength.

Establishing Waste Strength - infrequent sampling may lead to contestable estimates, some cities use a statistical approach to sampling.

Water Losses - water-meter based charges do not account for water losses in products or due to evaporation from cooling towers.

Surcharge Rates and Dilute Wastes - surcharge systems usually treat dilute wastes as though they were domestic strength.

Double Charging BOD and SS - a charge system relying on both BOD and SS double charges when SS loads also exert a BOD. This penalizes industry with a high BOD in particulate form. Use of the non-biodegradable SS parameter overcomes the double counting problem.

Rate Continuity - full adjustments in keeping with newly introduced rate structures are at times not made in order to avoid marked rate charges for certain user classes.

Garai, H. 1977. "Industrial Effluent Surcharging: A Case Study of Kitchener, Ontario." Journal of the Water Pollution Control Association 49(4):539-548.

The surcharge program for Kitchener is reviewed and evaluated. The charging formula, a function of BOD and SS concentrations is found to be potentially ineffective and inequitable because it allows firms to reduce their surcharge cost by diluting their waste stream particularly with waste cooling water which has already been purchased. Dilution with cooling water is not likely to be done in this case since the user would thereby lose a rebate of the sewer rate on the water bill that is offered for any water discharged to the storm sewer instead of the sanitary sewer.

A proposed revision of the charge formula would make the charge a function of loadings rather than concentrations and would do away with the wastewater strength threshold. These changes would eliminate inequities in the current program.

A review of industrial waste loadings suggests that pretreatment was introduced prior to implementation of the surcharge in response to regulatory bylaws.

Harkness, N. 1984. "Problems Associated with the Disposal of Trade Effluent to Sewers - Charging and Control." Water Pollution Control 83(3):367-375.

A broad overview of the history and practice of trade effluent controls in Britain is provided, including a discussion of policy and legislation as it has evolved from 1915.

Salient points relating to the use of the extra strength sewer surcharge include:

- Practices were ratified in 1976 by the Confederation of British Industry and the National Water Council. Published guidelines stipulated use of the Mogden formula to set rates with provisions for a minimum charge.

- Discharge permits typically set concentration and volume limits which are dependent on total system capacity and loading conditions.

- Wide discretion is used in the enforcement of limits and strict enforcement is not always deemed necessary as long as charges are paid.

- Effluent sampling requirements for enforcement and for setting charge levels differ since the first requires detection of violations while the second calls for sampling of representative waste streams. In practice one program, relying primarily on grab samples is used for both purposes.

- Variability of waste strength is identified as a major impediment to setting accurate charges. Examples are cited where several hundred samples would be required to assure a 90% confidence of being within 10% of an accurate charge level.

- Administration costs for charging and controlling trade effluents are estimated to be 10% of trade effluent income.

- Government policy regarding current cost accounting and generation of a return on investment for sewerage authorities have affected cost allocations and effluent charges.

Hudson, J.F., E.E. Lake and D.S. Grossman. 1981. Pollution-Pricing, Industrial Response to Wastewater Charges. Lexington Books, D.C. Heath and Co., Toronto (212 pages, with index and references).

This book documents a study of the sewer surcharge funded by the President's Council on Environmental Quality (contract EQ8AC029). Case study information for 101 firms in five cities was assembled based on personal interviews with industry and municipal officials.

The sewer surcharge programs under investigation were implemented between 1951 and 1970 in Atlanta, Chicago, Dallas, Salem, and South San Francisco. Objectives of the programs were the equitable allocation and recovery of treatment costs. Though programs met with some early opposition, they were generally well received in part as a result of concerted efforts at communication with industry during implementation.

Charges were levied for flow, and for concentrations of BOD (COD in one case) and total suspended solids in excess of "normal" concentrations. In Atlanta, no threshold levels for normal concentrations were used. In all cities, bylaws were used to regulate discharges of various other contaminants.

The range of unit charges across cities was as follows ($U.S. 1979):

flow - $.031 - .28/ccf
BOD - $.0181 - .105/lb
TSS - $.021 - .105/lb

These charges were set based on an analysis of actual and design costs for treatment, with methods for cost allocation varying considerably across cities.

A relatively small number of plants were monitored and charged in each city. The proportion of total customers who were eligible to be charged ranged from 0.08% to 0.20%, while those actually charged ranged from 0.02% to 0.12%. Chicago had the largest service population, 2 million customer, and the largest number of charged plants at 350.

Waste flows were monitored by either municipal staff or the plant itself and various mechanisms were in place for review and verification of monitoring results.

Annual monitoring and other municipal administrative costs varied from $0.02 to $1.2 million (U.S. $1979). This represents a per plant cost of $1,500 to $3,400 and accounted for 7% to 21% of collected surcharge revenues. Surcharge revenues in turn made up 3% to 26% of system revenues.

Surveyed firms were of the following types - meat packers, canneries, dairies, other food processors, chemical manufacturers, industrial laundries, paper and boxboard producers, metal finishers and other metal fabricators. Responses from industry led to the following conclusions (pg. 23):

- Charges are noticed at the plants, and there is a response.
- Some responses are administrative only, with no changes in wastewater flows and strength.
- Other responses attempt to reduce waste loads and are similar to those made in response to prices of other factors.
- There are significant differences in responses in the five cities.
- To some degree, plants in the same industry respond similarly.
- Responses were small; in only a few cases were the responses large; prices would have to be much higher to achieve large (80 percent) reductions in total effluent volume and strength.

- Nonresponse and fraud appear to be infrequent.
- There were cases of innovation in the responses.
- Conservation measures in wastewater, water, and energy seem generally to reinforce one another, and regulations on discharge components, such as toxics, generally also reduce discharges of BOD and TSS.
- Regulations on air pollution, solid waste disposal, pure foods and drugs, and safety seem to lead to larger amounts of discharge and higher charges than would otherwise be paid.
- There were significant differences between the responses made by local firms and by national firms producing similar products.
- There was limited evidence that the monitoring data from the charges could be used to improve plant operation; however, this potential was not realized, in part because of the low frequency (and sometimes limited quality) of the samples.
- Plant managers view the charges favourably, as part of the overall cost of production.

Based on overall study findings, the authors arrived at the following general conclusions (pg. 50):

> "the charge systems work from the perspective of the agencies involved, the plant managers who pay the charges, and outside evaluators, such as ourselves. From the outside perspective, much could be improved: rates probably do not closely reflect marginal or even average costs; the monitoring programs give only a questionable estimate of actual waste strengths and flows; information often moves slowly between systems and customers; and there are opportunities for cheating and some downward bias in the estimates. However, these are minor in relation to the strengths of the systems and to their accomplishments in both allocation and setting incentives for waste reduction. Relatively simple systems such as these can perform well, without excessive administrative costs."

Hulme, P., P.C. Johnson, D.G. Walker and J.C. Ellis. 1985. "Industrial Effluent Charging: How Many Samples?" Water Pollution Control 84(4):486-495.

This paper develops a rational method for determining industrial effluent sampling frequency based on statistical precision and net revenue concepts. The underlying relationship is the "Mogden" charge formula which multiplies "normal" COD and SS cost coefficients by the ratio of monitored to "normal" waste strengths. Given variance/covariance information for COD and SS effluent concentrations, an expression is derived for variance of the surcharge revenue from a particular source which is a function of sampling frequency.

This expression lends itself directly to determination of a sample size required to achieve a prospectively level of precision in estimating charge levels with a given level of confidence, for instance assuring a 90% likelihood that the estimated charge is within a given amount or percentage of the true charge. In this approach no consideration is given to the cost of sampling.

The authors then show how the variance expression can be incorporated into a net revenue framework that allows identification of a sample size that will minimize the expected revenue loss to the sewer authority from negative sampling errors (i.e. from sampling that underestimates the true strength of an effluent).

The formula is applied to data from 25 firms subject to a sewer surcharge. Existing charges for these firms are based on from 2 to 29 samples/year. The estimated precision of these charges (90% confidence) varies from 3.5% to 60%. To fix the precision to $\pm$10% or $\pm$ 100 (whichever is greater) certain sampling frequencies would fall while others would increase (up to 115/yr in one case). The same is true under the net revenue approach with a frequency of 130 suggested in two cases.

The article goes on to discuss errors in flow measurements and various other factors that could affect their results. A sensitivity analysis is provided.

Ingold, N.I. and N.G. Stonebridge. 1987. "Trade Effluent Charging - The Mogden Formula," Water Pollution Control, pp. 172-183.

The Mogden Formula, introduced in 1936 with the opening of the Mogden Works in West Middlesex, splits the cost of treatment into three elements: preliminary treatment and miscellaneous operations apportioned to flow (V), biological treatment apportioned to strength (B) and sludge treatment and disposal apportioned to solids (S). The total rate/m^3 is C = V + B + S. The rates, B and S, are based on average costs and are factored for industrial wastewater using the ratio of each discharger's effluent strength or solids concentration to mean concentrations as follows:

$$C = V + (M^i/M)\ B + s^i/s)S$$

The variables, s and s^i, measure settleable solids while M and M^i are now based primarily on COD though certain jurisdictions also use metals and cyanide concentrations to determine the factor for B.

The incremental costs of disposing of sludge contaminated with metals are examined. A metals factor applied to the sludge component of the formula is proposed to cover these costs.

Modification to the existing practices are evaluated. These include:

1. greater reliance on assumed waste strengths for classes of dischargers (i.e. no sampling of discharge);
2. use of a rolling average of past waste strengths to set rates (reduces sampling frequency);
3. use of standard charging bands for waste strength rather than a formula, selection of the band based on intensive sampling at first followed by occasional verification. Charge band rates could increase in a non-linear manner to discourage higher strength wastes.

Johnson, J.A. 1969. "The Distribution of the Burden of Sewer User Charges Under Various Charge Formulas." National Tax Journal XXII(4):472-485.

The use of user charge is promoted in the United States by legislation tying federal funding of water resource projects to local revenue generation using user charges. Such charges are advocated for various reasons including

- economic efficiency in resource allocation
- revenue generation
- improved equity (based on concepts of ability to pay or benefits received)

One user charge, the sewer service charge, is evaluated to determine the burden of the charge on various sewer users and to assess its performance based on equity, resource allocation, revenue generation and ease of administration. Ten charge formulas are considered; these are:

- two flat fee schemes
- four schemes based on water volume
- one scheme based only on BOD
- one combining BOD and water volume
- one combining BOD and water volume with an allowance for normal BOD discharges (a surcharge formula)
- a property tax scheme

The assessment of cost burden was based on a hypothetical application of these 10 schemes to data describing sewer customers in a large city in the eastern U.S. All charge levels were designed to generate a similar revenue level, and the analysis did not account for consumer response to charges. The residential burden varied from 33% (straight BOD charge) to 94% (flat fee) while the industrial share varied from 1% (flat fee) to 51%

(straight BOD charge). The food and chemical sectors bore the largest burden within industry under the water volume and BOD charge schemes.

Overall the BOD charge schemes rated high in terms of equity based on benefits-received, resource allocation and revenue obtained but low in terms of ease of administration and equity based on ability-to-pay. The flat fee was deemed easiest to administer and the property tax scheme was considered most equitable from the perspective of ability-to-pay.

Kibat, K.T. 1984. "Sewerage Charges and Effluent Taxes based on the Polluter Pays Principle." Korrespondenz Abwasser 31(8):708-713.*

The workings [in Germany] of the Effluent Tax Law and the implication of the polluter pays principle for small district authorities were examined in a specially commissioned survey among five such authorities responsible for drainage and sewerage services. Of particular interest was the way in which the Effluent Tax Charges levied on the sewage treatment undertaking were passed on to the indirect dischargers by the methods of levying charges for trade waste disposal to sewers, and the consequences of such charges in securing a reduction in the level of polluting discharges. It was concluded that the imposition of a surcharge on indirect dischargers would not lead to a general reduction in pollution levels and that only in a few special cases was the level of trade waste discharges likely to remain constant.

* Reference not located, abstract from AQUALINE.

Kremer, J.G. and D. Glasgow. 1979. "Industrial Waste Surcharge Program in Los Angeles County." Journal of the Water Pollution Control Federation 51(11):2626-2635.

This article documents a case study of sewer user charge implementation in Los Angeles County. Prior to the surcharge, sewerage revenues were generated through property taxes. Under this system industry generated about 35% of waste flows but paid only 11% of tax revenues.

The formula applied in this case used no lower threshold and therefore represented a true effluent charge. There was however a lump sum deduction from the total charge equivalent to the tax payment. The charge formula also incorporated a peak flow component to account for the cost of extra capacity to treat peak flows.

Unit charge rates for each component (flow, peak flow, COD and SS) were based on operating and capital costs with no allowance for interest costs.

Industries are grouped into three classes - insignificant dischargers who are exempt, minor dischargers who are charged based on typical industrial waste characteristics, and major dischargers who are charged using the charge formula. Self monitoring and reporting with municipal verification provides the basic information for calculation of charges. Annual auditing has uncovered very little fraud on the part of industry.

Lake, E.E., W.M. Hanneman and S.M. Oster. 1979. Who Pays for Clean Water? The Distribution of Water Pollution Control Costs. Westview Press, Boulder, Colorado.

This is a synoptic study of the incidence of water pollution control costs in the United States. Concepts of horizontal and vertical equity provide the basis for evaluating the incidence of changes in the public sector (higher taxes and user fees, reduction in other services) and the private sector (changed industrial prices) arising from the Water Pollution Control Act. Sewer surcharges are one of the sewer user fees considered in the report.

The discussion of sewer charges encompasses various types of charges (flat fees, volume/quality related charges, etc.). Aggregate sewer charge revenues collected by municipalities and sewer districts roughly matched non-capital sewerage expenditures in 1967 and 1972. For the districts alone, they amounted to 37% and 48% of operating plus debt service costs in 1967 and 1972 respectively.

Sewer charges were first used in Massachusetts in 1894. By 1969, 86% of cities with public sewerage used charges, and of these 67% of residential charge schedules and 81% of commercial and industrial charge schedules were based at least in part on water or sewage flows. Charges that were based on waste strength were allowed for in ordinances in 20% of 1160 surveyed cities but were actually levied in only 5% of these. The implementation of cost recovery provisions in a 1972 amendment of the Water Pollution Control Act is expected to increase the use of such charges.

In a 1973-74 survey of cities using the high-strength sewer charge, 74% of the respondents indicated that revenues from such charges covered the additional costs of treating associated industrial wastes.

The analysis of incidence of user charges revealed that 20% of charge revenues are collected from commercial and industrial users while 80% of revenues are collected directly from residences. In overall incidence, the user charge, which is typically comprised of 75% flat charges and 25% volume based charges, is slightly less regressive than a per capita or household tax and much less progressive than the property tax.

Leonard, R.L. 1973. "Pricing of Industrial Wastewater Treatment Services." Institute of Water Resources, University of Connecticut. Report No. 20 (64 pages, references).

This report describes a computer model that was developed to allocate the capital and O & M costs of municipal treatment systems in determining quantity/quality based charges for industrial sanitary effluents.

A brief review of cost allocation practices reveals considerable disparity in method. An underlying difference in approach involves whether the allocation of a particular system cost component is based on the waste loading parameters used for purposes of system design or on the intended function of the system component. For example, phosphorus removal apparatus might be designed based on flow volume and P concentrations. A design-based cost allocation would use both these parameters while a functional approach would allocate costs based only on P loadings.

The model presented in this report sets charge levels based on average costs of treatment. Average costs are allocated to flow and contaminant loading portions of the charge based on relative marginal costs of treating incremental flow and contaminant loadings. Either short-run (fixed capacity) or long-run (variable capacity) marginal costs may be used as the basis for the cost allocation.

The process design algorithms within the model consider several waste characteristics among which are flow volume, BOD, carbon, nitrogen and phosphorus. Cost models rely on 1960 U.S. E.P.A. statistical cost functions which are updated with price indices. Chemical oxygen demand is recommended as a more accurate determinant of system cost than BOD.

A hypothetical case study is used to demonstrate the proposed approach.

Maystre, Y. and J.C. Geyer. 1970. "Charges for Treating Industrial Wastewater in Municipal Plants." Journal of the Water Pollution Control Federation 42(7):1277-1291.

This paper reports on a 1969 survey of 221 American cities concerning use of the sewer surcharge and proposes a two step sewer surcharge program that maintains a reasonable degree of equity while remaining simple and administratively manageable.

From the survey, its was found that 10% of small cities (10,000 to 50,000 people), 15% of mid-size cities (50,000 to 200,000) and 20% of larger cities (>200,000) used the industrial sewer surcharge. While individual charge formulas varied considerably, they all used a common underlying approach relying on the application of a surcharge factor (or multiplier) to the normal sewer charge. These factors were estimated based on excess BOD and SS concentrations. The definition of normal BOD and SS concentrations was found to be "unsatisfactory" leading to results that were not equitable. For a typical industry, the surcharge was found to potentially vary by two orders of magnitude across municipalities.

To overcome this problem of equity, a two step surcharge procedure is advocated. Dischargers are grouped into three classes - domestic, normal industrial, and high-strength industrial. The allocation of firms among the two industrial groups is to be made so as to simultaneously minimize the number of firms in the high-strength group and the variability of waste strength across firms in the normal group. The reason for this is that high-strength waste dischargers must be individually monitored while other industries are assumed to have wastes of similar quality for purposes of charging.

Charge factors must be determined for domestic and normal industrial use as well as for individual extra-strength dischargers. These factors are applied to a nominal waste treatment charge per unit volume to determine charge levels for each group. Formula are provided to estimate charge factors and the nominal charge.

Miliszek, P. and H. Kotz. 1986. "Surcharge on Effluent Charges for Heavy Polluters - a Bavarian Proposal." Korrespondenz Abwasser 33(4):286-289.*

Sewerage charges for indirect dischargers [in Germany] were still largely based on the volume of effluent discharged to sewer. The costs might in fact be determined solely from the metered quantity of fresh water used on the premises. As industrial effluents were frequently more costly to treat than domestic sewage, it was proposed that where the additional cost of treatment was more than 30 percent above that for municipal sewage, a surcharge should be applied at a level dependent on the extra cost, on a sliding scale. Those operations for which costs were dependent on the level of pollution are discussed, and some typical examples showing the method of calculated the surcharge are included.

* Reference not located, abstract from AQUALINE.

Mount, T.L. 1979. "A Municipal Program to Control Industrial Waste." Presented at American Institute of Plant Engineers Water Pollution Contamination Control Conference, New Jersey, April 10.

This paper presents a case history concerning the introduction of an excess strength sewer surcharge by the Pennsauken Sewerage Authority (PSA) in Pennsauken, New Jersey. After introduction of an "Industrial Waste Ordinance" required under the PSA NPDES permit, the PSA decided to introduce a surcharge to recoup new industrial effluent sampling costs and to give industry some incentive to comply with the ordinance. Inconclusive evidence is provided regarding changes in compliance rates and observations are made regarding program implementation. The need to maintain good communications with industry is stressed.

Olliffe, J.J. 1963. "Sewer Service Charges and Surcharges." Journal of the Water Pollution Control Federation 35(5):607-613.

This paper is a case study of rate setting by a regional sewage treatment authority in Pennsylvania servicing 72 municipalities. Annual costs are compared to flows of sewage, infiltration and inflow to determine unit costs. These are carried into the rate structure to allocate total costs in proportion to sewage and other flows originating from each property. This exercise provides the basis for a block rate structure of basic charges to be applied to all customers.

Capital and operating costs for treatment are then apportioned between quantity and quality. A surcharge formula based on BOD and SS is used to factor the basic rate up for commercial and industrial clients with high-strength wastes.

Penman, A. 1974. "The Experience with the Effluent Charge Scheme of the City of Winnipeg." Presented to Department of the Environment, Hull, P.A., Reproduced in J. Donnan and P. Victor, 1976. "Alternative Policies for Pollution Abatement, The Ontario Pulp and Paper Industry." Vol. 2, Ontario Ministry of the Environment.

The history of attempts to control industrial discharges to Winnipeg's sanitary sewers is reviewed. Noncompliance and delay were endemic until economic incentives were introduced in 1958 by means of the extra-strength sewer surcharge.

Firms in 16 industries are sampled and 50 are charged under the program. In 1971, over $200,000 in fees were collected while labour costs for sampling were $14,500. Pretreatment was introduced in several plants after imposition of the surcharge.

The author argues in favour of a regulation that is firmly enforced and that offers no scope for discretionary application.

Public Works Engineer 1955. "Industrial Waste Disposal Charges in Cities over 5,000 Population." Special Report No. 18-S, American Public Works Association.

This report documents the findings of a survey of 256 U.S. cities. Of the sampled cities, 12.5% used a charge based on sewage quality and quantity, 71.5% used a quantity based charge and 16% used a flat charge. Of those not considering quality in their charge formula, 9.8% had bylaw provisions for a quality based charge.

Key features of rate structures are described such as minimum charges by water meter size, the basis for flat charges, and the range of factor values where charges are based on a percent factor applied to the water supply charge.

Cities reporting a surcharge based this primarily on BOD (5 day at 20°C) and suspended solids. Chlorine demand and hydrogen ion concentration were other constituents that recurred in rate structures. The majority of respondents used a surcharge format encompassing normal limits for waste strength. Unit rates ranged from $0.56 to $2.33 per 100 lbs of BOD and from $0.12 to $1.77 per 100 lbs of SS (U.S. $1955).

A number of bylaw regulations are also outlined. Among reporting cities, the following ranges were reported for sewage limits:

	No. of Obs.	Range of Values	Most Frequent Value
BOD	21	250 to 1000 ppm	300 ppm
SS	22	200 to 1500 ppm	350 ppm
Hydrogen ion	19	4.6 to 10.5 pH	5.5 to 9.5
Fat,grease,oil	24	100 to 1000 ppm	100 ppm
Max. temperature	18	90° to 150°F	150°F

Data on industrial pretreatment was provided by 34 respondents. For this group, a median value of 20% of all industrial discharges used pretreatment. Twenty-two cities reported on industrial discharge sampling frequency; 7 sampled monthly, 6 sampled every 6 months, and the remainder had sampling periods ranging from 2 months to 36 months.

Roderick, R.E. 1961. "Rate Structures for Industry." Journal of the Water Pollution Control Federation. 34(4):311-319.

An exercise is completed illustrating the development of a typical sewerage rate schedule based on the following design criteria:

- charges should be based on unit costs associated with the principal cost determinants, namely flow, BOD and SS;

- these unit costs should be applied uniformly to all customers

- the rate structure should account for peak load costs.

Costs are allocated to property as tax and to sewer users as a user charge. The property allocation accounts for that portion of costs resulting from storm water flows which enter sanitary sewers and also for reserve capacity costs for future growth of the community. The allocation to user charges is based on flow, BOD and SS and reflects engineering judgement regarding the function of various components of the sewerage system.

Typical unit charges for flow, BOD and SS are calculated. These provide the basis for estimation of monthly charges to domestic customers and a range of industrial customers. The charge formula uses total loadings rather than loadings in excess of a threshold.

Shaw, R.E. 1970. "Experience With Waste Ordinance and Surcharges at Greenboro, N.C." Journal of the Water Pollution Control Federation 42(1):44-50.

A greater degree of control over sanitary sewer discharges was considered necessary after construction of a new sewage treatment plant. In 1961, an ordinance controlling the quality of effluents was adopted and provision was made to impose a charge on extra-strength effluents (BOD and SS). The sewage customer was required to provide property access and to pay for the installation of monitoring devices.

Surcharge levels were based on an allocation of capital and operating costs to flow, BOD and SS. A separate 75% surcharge on the water bill was considered adequate for recovery of treatment costs on normal strength wastes.

Ongoing monitoring procedures were established for large sources while a sampling of small sources was used to establish charge levels for classes of users such as laundromats.

Industrial effluents accounted for 17% of total sewage flow, 49% of BOD loads and 28% of SS loads. Program administration cost $18,067 ($1968-69 U.S.) and revenues for the same period were $113,101. Since 1961, surcharge revenues have exceeded the cost of capital improvements or alternatively have made up 32% of operating costs (excluding depreciation).

Industry was granted a six month period to adjust their operations prior to imposition of the charge. During this period, municipal resources were provided to assist industry. Several decisions to pretreat are reviewed.

Sidwick, J.M. 1982. "The Discharge of Industrial Effluents to the Public Sewer." In Volume 1 of Water Resource Management in Industrial Areas, International Water Resources Association Report. pp 376-384.

Since empowering legislation in 1974 - namely the Control of Pollution Act - British Regional Water Authorities (RWA) control virtually every industrial effluent discharged into public sewers. They are responsible for monitoring, charging and enforcement of standards. Objectives for control, established by the Confederation of British Industry and the RWA's, are:

- to prevent damage to sewerage system and personnel, interference with treatment processes, adverse affects on water resources, and unacceptable storm water discharges,
- to provide design data,
- to allocate treatment cost equitably

The implementation of controls is characterized by a pragmatic and flexible approach that can accommodate circumstances specific to discharges and to sewerage systems. Charge formula are generally based on the Mogden formula:

$$C = V + B\ (OD_t/OD_s) + S\ (SS_t/SS_s)$$

where

C = total cost of treatment per m^3 of trade effluent

V = costs related to the volume of flow per m^3 of mixed crude sewage

B = costs related to aerobic biological treatment per m^3 of sewage

OD_t = oxygen demand (strength) of trade effluent in mg/l

OD_s = oxygen demand (strength) of settled sewage in mg/l

S = costs related to sludge treatment per m^3 of sewage

SS_t = suspended (or settleable) solids in trade effluent in mg/l

SS_s = suspended (or settleable) solids in crude sewage mg/l

General requirements governing the quality of sanitary sewer discharges are given.

Sims, W.A. 1979. "The Response of Firms to Pollution Charges." Canadian Journal of Economics, XII(1):57-74.

Sims examines the behaviour of a cost minimizing firm faced with a sewer surcharge on waste effluents. A theoretic argument is presented to demonstrate the potential for cost savings by means of dilution of wastes when there is a threshold concentration level below which the charge does not apply. The threshold is viewed as a market distortion.

Evidence that such a tendency exists is provided using cost and production data from Canadian breweries. Estimated relationships without the market distortion suggest that a one percent increase in the charge on BOD or SS would lead to 0.57% and 0.45% declines in emissions of BOD and SS respectively. Similarly, a one percent increase in the cost of water for waste dilution results in a 0.95% decrease in water use. With allowance for a normal strength waste, the responsiveness to the BOD and SS charge is reduced to 0.56% and 0.44% respectively, while the demand for dilution water increases by 0.044% and 0.062% in response to a 1% increase in BOD and SS charge levels.

Sims, W.A. 1979. "The Welfare Loss of an Input Market Distortion: The Case of Sewer Effluent Charges." Land Economics 55(3):379-387.

A net welfare loss to society is created by market distortions such as the allowance for normal strength wastes in typical sewer surcharge programs. The amount of this loss is demonstrated first using the standard micro-economic format of the production saturant. The author then shows how an equivalent measure of this loss can be represented using a demand curve for the production input that is subject to the price distortion (water for waste dilution in this case). An empirical measure of this welfare loss is calculated for a hypothetical brewery in London, Ontario; it amounts to $0.065/1000 gallons of water used for dilution.

Taylor, C.C. 1972. "Industrial Waste Treatment Charges for Users as Required by the Environmental Protection Agency." The Georgia Operator. Spring.

E.P.A. regulations governing cost sharing arrangements for Federal-grant facilities are reviewed. Objectives of the regulations are:

- distribute costs in proportion to benefits received
- assure financial capability to construct and operate the facility
- promote awareness of the need to pay for water treatment
- promote volume and loading based charges
- encourage municipal self-sufficiency in sewerage services.

The regulations apply only to locally incurred costs and require that these be shared by all beneficiaries of the service including non-users. Costs not allocated to current users, such as are associated with reserve capacity for future growth, are assessed against the whole community. Industrial users should share capital costs in proportion to capacity designed to serve them, with appropriate considerations made for peak loadings. Sources of revenues and collection methods are not specified but user charges and industrial surcharges based on average costs of treatment are encouraged.

Technical Practice Committee. 1982. "Sewer Charges for Wastewater Collection and Treatment - A Survey." Water Pollution Control Federation, Washington, D.C.

This report reviews the basis for establishing sewer service, user charges and presents the results of a rate survey of 66 U.S. cities. Surveyed cities range in size from a population of 4400 to 5.4 million.

Two thirds of the 66 respondents used some form of extra-strength sewer surcharge for industry. Four cities reported a discharge inspection fee for industry.

With regards the extra-strength sewer surcharge, the report notes that in addition to BOD, COD and SS, a number of other constituents are appearing in charge formulas. Examples cited include ammonia, oil and grease, and maximum flow.

Upton, C. 1971. "Application of User Charges to Water Quality Management." Water Resources Research 7(2):264-272.

This paper presents a hypothetical analysis of the efficiency losses attending the use of user charges as opposed to optimal taxes for control of instream water quality. The setting comprises a section of the Miami River in Ohio along which 15 major dischargers impair instream dissolved oxygen levels. Remedial measures include treatment for BOD removal by each discharger or reservoir construction for low flow augmentation.

Optimal taxes on pollutant discharge equal the marginal cost of alternative treatment methods (including low-flow augmentation) while user charges are assumed to be equal to average treatment costs. Two user charge formulations are investigated as well as the optimal tax. These formulations define average cost using respectively total and incremental discharges.

Optimal taxes will not necessarily generate enough revenue to finance low flow augmentation by the central authority but it will conceivably generate an efficient mix of treatment methods.

The efficiency losses of resorting to the user charge, which does generate adequate revenue, are determined for a range of alternative water quality targets using synthetic cost data. The efficiency loss for a user charge scheme based on average costs defined using total discharges varies from 2% to 10%.

W.P.C.F. Task Force on Financing and Charges. 1984. "Financing and Charges for Wastewater Systems." Water Pollution Control Federation, Am. Soc. of Civil Engineers, Am. Public Words Asc., Washington, D.C.

This publication provides a general discussion of financial management for sewer authorities including a discussion of rate setting procedures.

The rate setting exercise is characterized as a two step process:

1. allocation of costs to cost-causing factors including inflow/infiltration, number and type of existing and future customers, average and peak wastewater volumes, average and density of the collection system, wastewater strength and sludge quality.

2. Distribution of allocated cost components to customer classes and estimation of unit rates for each class.

The discussion of wastewater strength as a factor affecting costs focuses on BOD and SS. the rationale for allocation of costs for treatment plant components to these and other cost factors is reviewed and a detailed example is provided showing cost allocation and rate setting for each customer class. The example illustrates how extra-strength surcharge rates are derived in the rate setting exercise.

Walter, C.R. 1963. "Determination of Charges and Surcharges for Waste Treatment." Journal of the Water Pollution Control Federation 35(9):1105-1111.

This paper documents a surcharge estimation exercise for a city of 120,000 people. The city collects some revenues from property tax assessments for construction of lateral sewers but remaining sewerage costs are charged directly to users.

Allocation of sewerage cost components, including operating, maintenance and debt servicing costs, was based on engineering judgement. Using calculated charge levels and the characteristics of industrial discharges, revenue from the surcharge was forecast over six years. These were subtracted from revenue requirements and the resulting net revenue requirement levels were used to estimate a volume based sewer surcharge level associated with the water bill.

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APPENDIX B

EXTRA-STRENGTH SEWER SURCHARGE MUNICIPAL SURVEY

- METHODOLOGY AND DATA SUMMARY

METHODOLOGY

Steps in this survey included:

- Design of english and french questionnaire forms and covering letters including pre-test and reviews with client (see Figure B.1)

- Collection of background data and preparation mailing addresses for operating authorities using MUNDAT

- Administration of questionnaire

  - mail-out of questionnaire package from Ecologistics' offices, packages included covering letter from MOE, questionnaire form and return envelope

  - a follow-up letter was sent out to all questionnaire recipients who had not responded after six weeks (see Figure B.2)

  - a phone call follow-up after eight weeks to municipalities who had not responded but who are known to use surcharges

- Coding and Analysis

  - a computerized master list was created using dBase III Plus software to generate mailing labels and to record follow-up actions and the receipt of completed questionnaires

  - returned questionnaires were checked for errors and omissions, coded and entered into a Lotus 123 database

  - summary statistics were generated for the complete data set and for cross-tabs.

Response rates are given in Table 1.2 in the main body of the report while summary statistics for responses are given in Table B.1. These statistics are for respondents reporting that sewerage services are provided.

FIGURE B.1 MUNICIPAL QUESTIONNAIRE INTRODUCTORY LETTER

Ontario
Ministry of the Environment
Ministère de l'Environnement

135 St. Clair Avenue West
Suite 100
Toronto, Ontario
M4V 1P5

135, avenue St. Clair ouest
Bureau 100
Toronto (Ontario)
M4V 1P5

October 5, 1987

Dear Sir/Madam:

The Ontario Ministry of the Environment has launched an ambitious program under the Municipal-Industrial Strategy for Abatement (MISA) to achieve the "virtual elimination of toxic contaminants in municipal and industrial discharges into waterways".

To help implement this program, the Ministry has commissioned studies of current practices used to regulate industrial discharges to sanitary sewers. The attached questionnaire is part of an assessment of the use of the extra-strength sewer surcharge. This nation-wide survey includes all municipalities with population in excess of 4,000.

Responses to this questionnaire will be used to identify and characterize existing surcharge programs, to determine their effectiveness, and to help generate guidelines for a model extra-strength surcharge program. A summary report of the study findings will be sent to all questionnaire respondents who request one and who mark the appropriate box on the questionnaire. Data from this survey will be provided to Environment Canada in order to update certain Municipal Waterworks and Waste Waster System files.

We would be most grateful if you would arrange to have this questionnaire completed by appropriate personnel in your municipality who are responsible for <u>waste water collection and treatment services</u> and for the <u>billing of industrial customers</u> for these services.

We ask that the questionnaire be returned within three weeks to Mr. Mike Fortin of Ecologistics Limited in Waterloo, Ontario using the self-addressed envelope enclosed for this purpose.

If you have any questions, please feel free to contact Mr. Fortin at (519) 886-0520 or our liaison officer for this project, Mr. George Zegarac at (416) 323-4578.

Thank you in advance for your cooperation.

Yours truly,

Donald Jeffs
Director
Policy and Planning Branch

Enclosure

FIGURE B.1 MUNICIPAL QUESTIONNAIRE FORM

for office use

NATIONAL MUNICIPAL WASTE WATER
SURVEY - INDUSTRIAL
SEWER USE REGULATION

SECTION 1 - GENERAL INFORMATION

THIS QUESITONNAIRE SHOULD BE COMPLETED BY A REPRESENTATIVE OF THE AGENCY OR DEPARTMENT WITHIN A MUNICIPALITY THAT DEALS WITH COMMERCIAL/INDUSTRIAL CLIENTS IN THE PROVISION OF SANITARY WASTE WATER SERVICES (EG. BILLING, CONNECTIONS, ETC.).

1. Indicate whether sanitary waste disposal services are provided in your municipality.

   1 ☐ YES   2 ☐ NO

IF NO, DISREGARD REMAINING QUESTIONS AND RETURN THIS PAGE OF THE QUESTIONNAIRE.

2. Please provide the name and address of your agency or department if the information on the label above is incorrect:

   Name of Operating Authority
   Street/P.O. Box
   City, Province
   Postal Code

3. Who is an appropriate contact person in this office?

   Name
   Position
   Telephone No.

4. Identify the municipal government structure that best describes your municipality.

   1 ☐ unincorporated village or district
   3 ☐ regional municipality - lower tier
   2 ☐ incorporated municipaltiy (single tier)
   4 ☐ regional municipality - upper tier
   5 ☐ special district established to provide sewer services

5. What components of the sanitary collection and treatment system do you maintain and operate?

1 ☐ main collection system
2 ☐ trunk sewers
3 ☐ interceptor sewers
4 ☐ treatment plants(s)
5 ☐ other ____________________
6 ☐ none

6. a) If another agency is wholly or partly responsible for treatment plant operations, give the name and address of that agency:

Name of Operating Authority
Street/P.O. Box
City, Province
Postal Code
Telephone No.

b) If another department is responsible for customer billing, please give the name, position and phone number of a contact person in that department:

Name
Position
Telephone No.

7. What is your total service population?

8. Please indicate, by type, the number of sanitary service accounts that you deal with directly in terms of billing for services, addressing complaints, etc. (indicate no. of municipalities served if you don't deal directly with customers):

1 domestic
2 commercial
3 industrial
4 other municipalities
5 other ____________________
6 total

9. Please indicate the approximate proportion of average daily discharge to your sanitary sewers received from each of the following classes of users: (total of these percentages = 100%)

1 % Domestic (residential)
2 % Commercial/Institutional/Public
3 % Industrial
4 % Other ____________________

FIGURE B.1 - cont'd

10. a) How many treatment plants are there in your system? ☐☐

b) What percentage of total sanitary sewage flow is treated in each of the following types of treatment plant?

☐☐☐ no treatment
☐☐☐ lagoon
☐☐☐ primary
☐☐☐ primary with P removal
☐☐☐ secondary
☐☐☐ secondary with P removal

tertiary (describe)
☐☐☐ ____________________
☐☐☐ ____________________

other (describe)
☐☐☐ ____________________
☐☐☐ ____________________

c) Indicate the combined flows for all plants:

	flows?	units?
total design capacity flow	☐☐☐☐☐☐	☐☐☐☐
total average daily flow	☐☐☐☐☐☐	☐☐☐☐
total maximum daily flow	☐☐☐☐☐☐	☐☐☐☐

d) What is your method of sludge disposal?

☐ Disposal on crop land
☐ Buried at landfill site
☐ Land farming
☐ Incineration
☐ Other ____________________

FIGURE B.1 - cont'd

SECTION 2 - REGULATION OF INDUSTRIAL DISCHARGES

IF YOU DO NOT HAVE ANY INDUSTRY, GO TO SECTION 6 ON PAGE 15.

11. How frequently have the following problems arisen over the past five years in the collectors or treatment plant(s) as a result of industrial sanitary discharges?

	1 Never	2 Infrequent	3 Frequent	
1	☐	☐	☐	Excessive loadings of BOD and SS
2	☐	☐	☐	Physical blocking or clogging of collectors and treatment facilities
3	☐	☐	☐	Excessive foaming in collectors and treatment facilities
4	☐	☐	☐	Odours
5	☐	☐	☐	Toxic Gases
6	☐	☐	☐	Excessive corrosion of collector system
7	☐	☐	☐	Toxic upset of aerobic or anaerobic treatment systems
8	☐	☐	☐	Excessive volume of discharge
9	☐	☐	☐	High temperature discharges
10	☐	☐	☐	Toxic substances passing through into effluent
11	☐	☐	☐	Toxic substances passing through into sludge

12. Are there municipal bylaws, provincial regulations or special contractual agreements with firms governing the nature of industrial discharges to the sanitary sewer?

1 ☐ Municipal Bylaws   2 ☐ Provincial Regulations   3 ☐ Special Agreements   4 ☐ None

IF THERE ARE NO SUCH BYLAWS, AGREEMENTS OR REGULATIONS, GO TO SECTION 3.

IF BYLAWS OR REGULATIONS ARE IN FORCE, PLEASE ATTACH A COPY OF THESE TO THE QUESTIONNAIRE FORM AND ANSWER THE FOLLOWING QUESTIONS:

13. Indicate the bylaw limits or maximum allowable concentrations for the following parameters:

1 ☐☐☐☐ mg/l BOD   3 ☐☐☐☐ mg/l Suspended Solids   5 ☐☐☐☐ mg/l Phosphorus

2 ☐☐☐☐ mg/l Grease and Oil   4 ☐☐☐☐ pH (lower limit)   6 ☐☐☐☐ pH (upper limit)

14. What criteria are used to identify firms as potential bylaw violators? (Check as many as are appropriate.)

1 ☐ none, not applicable   3 ☐ certain industrial sectors

2 ☐ all wet industries   4 ☐ other ________________

FIGURE B.1 - cont'd

15. How are bylaw violations detected? (Check as many as appropriate.)

1 ☐ no detection program in place
2 ☐ plant inspections
3 ☐ discharge sampling and analysis
4 ☐ other ________________

16. If discharge sampling and analysis are used to detect violations:

a) How many samples were collected and analysed in 1986?

1 ☐☐☐☐☐ grab
2 ☐☐☐☐☐ 8 hr composite
3 ☐☐☐☐☐ 24 hr composite
4 ☐☐☐☐☐ other ________

b) How many samples in violation are generally required to trigger enforcement activity for the following types of parameters?

1 ☐☐☐ BOD, SS, P
2 ☐☐☐ Metals
3 ☐☐☐ Toxics
4 ☐☐☐ pH

17. How is the bylaw enforced? (Check as many as appropriate.)

1 ☐ warnings and negotiations
2 ☐ prosecution and fines
3 ☐ orders from provincial agency
4 ☐ not enforced
5 ☐ need for enforcement has not arisen
6 ☐ other ________________

18. How many firms were subject to inspection and monitoring in 1986? ☐☐☐☐

19. How many violators were dealt with in 1986? ☐☐☐☐

20. How many prosecutions were made under the bylaw in 1986? ☐☐☐☐

21. What is the maximum fine per violation allowed under the bylaw? $ ☐☐☐☐☐☐

22. What were the average and maximum fines levied in 1986? Ave. $ ☐☐☐☐☐☐ Max. $ ☐☐☐☐☐☐

23. Check which, if any, of the bylaw limits can be exceeded by industrial dischargers under agreement with the operating authority: 1 ☐ None

2 ☐ BOD
3 ☐ SS
4 ☐ pH
5 ☐ grease, oil
6 ☐ Phosphorus
7 ☐ Others (which) ________________

FIGURE B.1 - cont'd

SECTION 3 - USER CHARGES

A USER CHARGE IS ANY CHARGE, INCLUDING TAXES, USED TO COLLECT REVENUE FROM USERS; AND AN EXTRA-STRENGTH SEWER SURCHARGE IS A USER CHARGE BASED ON THE STRENGTH OF WASTE WATER DISCHARGES.

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24. What type of charge is used to collect revenues from industrial sewer users? (Check as many as appropriate.)

- ☐ 1 none
- ☐ 2 tax based on assessed property value
- ☐ 3 special tax levy for sewer users
- ☐ 4 negotiated fee for service
- ☐ 5 fee based on charges for water supply
- ☐ 6 separate flat fee for waste water services
- ☐ 7 charge based on waste water discharge volume
- ☐ 8 extra-strength sewer surcharge
- ☐ 9 other ____________________

25. If charges to industry for waste water services are based on the water supply charges:

a) How is the water supply charge determined for industrial customers?

☐ 1 flat fee ☐ 2 charge based on volume of water consumed ☐ 3 not applicable

☐ 3 other ____________________

b) Is the sewer charge on the water bill reduced to account for any purchased water that is not discharged to the sanitary sewer (e.g. discharges to surface waters or storm sewers):

☐ 1 Yes ☐ 2 No ☐ 3 no such firms, not applicable

26. Is there any form of special payment to the operating authority from firms who discharge extra-strength wastes?

☐ 1 none ☐ 2 extra-strength sewer surcharge ☐ 3 negotiated payment

27. If an extra-strength sewer surcharge is not now in use, do your bylaws allow for one to be used?

☐ 1 Yes ☐ 2 No ☐ 3 not clear in bylaw

IF YOU DO NOT USE AN EXTRA-STRENGTH SEWER SURCHARGE, GO TO SECTION 6 ON PAGE 15, OTHERWISE GO TO PAGE 7.

SECTION 3A - USER CHARGES - THE SEWER SURCHARGE

28. In what year was the extra-strength sewer surcharge established? ☐☐☐☐

29. How long did it take to design and implement the surcharge program? ☐☐ (Months)

30. Why was a surcharge program established? (Check as many as appropriate.)

1 ☐ revenue generation
2 ☐ fair allocation of costs to users
3 ☐ penalize high strength waste dischargers
4 ☐ promote pre-treatment by dischargers
5 ☐ other ______________________
____

31. a) Who is covered under the surcharge program?

1 ☐ Applies to all industrial customers who may be discharging high strength wastes
2 ☐ Applies only to customers in certain designated industrial sectors [go to part b)]
3 ☐ Other coverage criteria ______________________

b) If only certain sectors are targetted, please specify which industrial sectors:

1 ☐ meat packing
2 ☐ paper and paper products
3 ☐ beverages
4 ☐ other food processors
5 ☐ other sectors (describe) ______________________

32. How much lead time was industry given to adjust operations before surcharge costs were imposed?

☐☐ Months

33. Was there an information program to advise industry of the nature and intent of the program?

1 ☐ Yes   2 ☐ No

34. Were there negotiations with industry concerning the design of the program?

1 ☐ Yes   2 ☐ No

FIGURE B.1 - cont'd

35. Were any other changes made to regulate industrial discharges to sanitary sewers when the surcharge was introduced?

- 1 ☐ no other changes
- 2 ☐ change in allowable concentrations under existing bylaw
- 3 ☐ expansion of bylaw enforcement program
- 4 ☐ other ______________________________

36. Indicate how frequently the following types of opposition were encountered when the program was introduced.

	1 Never	2 Infrequent	3 Frequent	
1	☐	☐	☐	complaints to the city about the high surcharge cost
2	☐	☐	☐	complaints to the city about the complexity of the charge
3	☐	☐	☐	complaints to the city that the cost was not fair
4	☐	☐	☐	complaints to the city about investigation and discharge monitoring requirements
5	☐	☐	☐	challenges to the surcharge in the courts
6	☐	☐	☐	request for a rate review to a provincial commission or board
7	☐	☐	☐	refusal to pay the surcharge
8	☐	☐	☐	other ______________________________

37. How is waste strength determined for purposes of setting the charge?

- 1 ☐ discharge sampling and analysis for all firms in the program
- 2 ☐ discharge sampling and analysis for larger dischargers and representative waste strengths assumed for others
- 3 ☐ representative waste strengths assumed for all firms

38. Who is responsible for discharge sampling and analysis?

- 1 ☐ municipality (single tier or lower tier)
- 2 ☐ region (upper tier)
- 3 ☐ province
- 4 ☐ discharger
- 5 ☐ not applicable

FIGURE B.1 - cont'd

39. Who is responsible for installation of man-holes or other access facilities for sampling?

1 ☐ municipality (single tier or lower tier)
2 ☐ region (upper tier)
3 ☐ province
4 ☐ discharger
5 ☐ not applicable

40. Does sampling for the surcharge program also serve as the principal sampling effort used to detect bylaw violations?

1 ☐ Yes
2 ☐ No
3 ☐ not applicable

41. Who is responsible for auditing to verify sampling results?

1 ☐ municipality (single tier or lower tier)
2 ☐ no auditing done
3 ☐ province
4 ☐ not applicable
5 ☐ region (upper tier)

42. How many samples were analysed per firm in 1986?

1 ☐☐☐☐ greatest number of samples per firm
2 ☐☐☐☐ least number of samples per firm
3 ☐☐☐☐ average number of samples per firm

43. Indicate the total number of samples, by type, analysed for the surcharge program in 1986:

1 ☐☐☐☐☐ grab
2 ☐☐☐☐☐ 8 hr composite
3 ☐☐☐☐☐ 24 hr composite
4 ☐☐☐☐☐ other ______________

44. How are waste water volumes determined?

1 ☐ volume not determined
2 ☐ metering of water supply
3 ☐ metering of waste water discharge
4 ☐ estimated from process data
5 ☐ other ____

45. How many firms were monitored under the surcharge program in 1986? ☐☐☐☐

46. How many firms were charged for extra strength wastes under the program in 1986? ☐☐☐☐

47. What were the total revenues collected under the surcharge program in 1986? $ ☐☐☐☐☐☐☐

FIGURE B.1 - cont'd

48. What is the billing period for the surcharge?

1 ☐ monthly   2 ☐ bimonthly   3 ☐ quarterly   4 ☐ trimester

5 ☐ other ______________________________

49. Please indicate which of the following ranges of surcharge costs are representative of billings to firms in each billing period:

	1 less than $150	2 $150 to $400	3 $400 to $1000	4 $1000 to $2500	5 $2500 to $7500	6 $7500 to $20 000	7 $20 000 to $50 000	8 Greater than $50 000
minimum bill	1 ☐	☐	☐	☐	☐	☐	☐	☐
most frequent bill size	2 ☐	☐	☐	☐	☐	☐	☐	☐
maximum bill	3 ☐	☐	☐	☐	☐	☐	☐	☐

50. How many staff years were required to support monitoring and other surcharge program activities in 1986? ☐☐☐

SECTION 4 - SURCHARGE RATE STRUCTURE

PLEASE ENCLOSE A COPY OF THE EXTRA STRENGTH SURCHARGE BYLAW AND ANY SUPPORTING DOCUMENTATION GIVING THE CHARGE FORMULA AND CURRENT CHARGE RATES.

51. Indicate which parameters are included in the charge formula, and the concentration threshold above which the charge applies.

	Check if used in formula	Threshold concentration for charge (≥ zero)	
BOD	1 ☐	☐☐☐☐	mg/l
COD	2 ☐	☐☐☐☐	mg/l
SS	3 ☐	☐☐☐☐	mg/l
Grease and Oil	4 ☐	☐☐☐☐	mg/l

	Threshold concentration for charge (≥ zero)	Measurement Unit
Other ______	☐☐☐☐☐	☐☐☐☐
______	☐☐☐☐☐	☐☐☐☐
______	☐☐☐☐☐	☐☐☐☐

52. How are unit rates determined in the surcharge formula?

1 ☐ based on analysis of waste water collection and treatment system costs

2 ☐ based on analysis of surcharge program costs (i.e. monitoring, administration)

3 ☐ based on collection and treatment system costs plus surcharge program costs

4 ☐ based on charge levels reported by other agencies

5 ☐ based on revenue generation targets that are not related to program or system costs

6 ☐ other ____________________

____

FIGURE B.1 - cont'd

IF CHARGE LEVELS ARE BASED ON AN ANALYSIS OF COLLECTION AND TREATMENT COSTS, PLEASE ANSWER QUESTIONS 53 AND 54, OTHERWISE GO TO SECTION 5.

---

53. What categories of cost are included:

	1 Capital	2 O & M	3 Overhead
Treatment	☐	☐	☐
Collection	☐	☐	☐

54. If more than one parameter is included in the charge formula (e.g. BOD and SS) then what rationale is used to allocate treatment costs between these parameters in order to derive factors for the charge formula:

1 ☐ based on relative importance of each parameter in design of treatment system components

2 ☐ based on function of system components in reducing concentrations of each parameter

3 ☐ based on both design and function

4 ☐ other ______________________________

____

5 ☐ not applicable

FIGURE B.1 - cont'd

SECTION 5 - SURCHARGE PROGRAM IMPACTS

55. Indicate which, if any, of the following treatment plant impacts are thought to have occurred as a result of the introduction of a surcharge program (please describe and attach any documentation of available data such as per cent loading reduction data):

1 ☐ no changes detected - Why? ____________________

____

2 ☐ reduced hydraulic loading - comment ____________________

3 ☐ increased hydraulic loading - comment ____________________

4 ☐ reduced loading of BOD - comment ____________________

5 ☐ reduced loading of SS - comment ____________________

6 ☐ reduction of operating costs - comment ____________________

7 ☐ reduction of capacity requirements - comment ____________________

8 ☐ delay of planned capacity expansion - comment ____________________

9 ☐ reduced loading of other contaminants - comment ____________________

10 ☐ other ____________________

____

FIGURE B.1 - cont'd

56. Approximately how many firms are known to have responded to the surcharge in the following ways?

1 ☐ no information on industry response

2 ☐☐☐ conducted studies to reduce surcharge costs

3 ☐☐☐ changed raw material inputs

4 ☐☐☐ changed production processes

5 ☐☐☐ used more water to dilute waste flows

6 ☐☐☐ analysed waste streams to verify charge levels

7 ☐☐☐ recovered waste products for reuse or sale

8 ☐☐☐ installed pre-treatment systems

9 ☐☐☐ used less water

10 ☐☐☐ improved general housekeeping practices

11 ☐☐☐ other ____________________

____

57. In total, approximately how many firms took positive action to modify their waste water discharge in response to the surcharge program? ☐☐☐☐

FIGURE B.1 - cont'd

SECTION 6 - OPERATING AUTHORITY FINANCES

58. Please indicate the total operating and maintainance costs of waste water collection and treatment services for the calendar year of 1986 or the fiscal year ending March 31, 1987. Where costs are only available combined with other costs, please estimate how much of these combined costs are for sanitary services. Required costs should include:
    - salaries, wages and benefits
    - repair and maintenance costs
    - supplies and services
    - power

	O & M
wastewater collection	$ ☐☐☐☐☐☐☐☐ 1
treatment and sludge disposal	$ ☐☐☐☐☐☐☐☐ 2
Industrial Monitoring (sample collection and analysis)	$ ☐☐☐☐☐☐☐☐ 3
Total Costs	$ ☐☐☐☐☐☐☐☐ 4

59. If the treatment plant or other portions of the system are operated by another agency, what portion of total costs represent payments to that agency for their services?

    $ ☐☐☐☐☐☐☐☐

60. Do figures above represent the cost for:

    1 ☐ calendar year 1986, or   2 ☐ fiscal year ending March 31, 1987?

61. Have the cost figures here been estimated from a "combined cost figure" as described above?

    1 ☐ Yes   2 ☐ No

FOR THOSE WHO RETURN A COMPLETED QUESTIONNAIRE, A SUMMARY OF QUESTIONNAIRE RESULTS CAN BE SENT TO THE ADDRESS ON PAGE 1. DO YOU WISH TO RECEIVE THIS SUMMARY? 1 ☐ YES 2 ☐ NO

---

ecologistics limited PLANNERS, LANDSCAPE ARCHITECTS, AND ENVIRONMENTAL SCIENTISTS

Westmount Place, 50 Westmount Road N., Suite 225, Waterloo, Ontario N2L 2R5 Tel. (519) 886-0520

November 24, 1987

Dear Sir:

On October 5, 1987, we mailed a questionnaire to you with a covering letter from the Ontario Ministry of the Environment. This questionnaire is part of a national survey concerning the municipal regulation of industrial waste water discharge to sanitary sewers. It forms part of Ontario's ongoing initiative to control hazardous emissions to watercourses from municipal and industrial sources - the Municipal/Industrial Strategy for Abatement (MISA).

As of the date of this letter, we had not yet received a response from your municipality. We are writing you now to encourage you to send in your completed questionnaire form.

The questionnaire is unfortunately long and detailed and we understand that it will take time to fill out. It is nevertheless important that the questionnaires be returned in order that our analysis be based on a realistic view of current municipal practices. Moreover you can benefit directly from the study to the extent that study findings will be mailed back to respondents who express an interest in receiving these.

If you have completed the questionnaire or are doing so now, we thank you for your interest and effort. If not, we once again urge you to do so. We have enclosed another copy of the questionnaire in case the first has been misplaced.

If you decline to respond, please send back this correspondence with a note for our files.

Sincerely,

ECOLOGISTICS LIMITED

Mike Fortin

M. Fortin, M.A.
Senior Economist

MF/db

Table B.1 SUMMARY STATISTICS FOR MUNICIPAL QUESTIONNAIRE

SECTION 1

		QUE. 1	QUE. 2	QUE. 3	QUE. 4	QUESTION 5						QUE. 6A	QUE. 6B	QUE. 7 (POP.)	QUESTION 8 (NO'S OF ACCOUNTS)								QUESTION 9 (% OF EFFLUENT FLOW)					
						1	2	3	4	5	6				DOM	COM	CO+DOM	IND	CO+IND	MUN	OTHER	TOTAL	DOM	COM	CO+DOM	IND	CO+IND	OTHER
CAN	SUM	192	121	189	427	173	138	80	132	28	1	69	107	10499329	1252004	65492	19815	20384	31419	88	2437	631101	9837	2072	357	2062	350	317
	COUNT	192	122	199	192	173	138	81	132	30	1	70	108	189	135	122	3	87	8	18	27	52	144	126	6	102	7	20
	AVG	1	1	1	2	1	1	1	1	1	1	1	1	55552	9274	537	6605	234	3927	5	90	12137	68	16	60	20	50	16
	MIN	1	0	0	1	1	1	0	1	0	1	0	0	500	1	2	1245	1	1000	0	0	0	20	1	39	0	37	1
	MAX	1	1	1	5	1	1	1	1	1	1	1	1	2072738	155000	16707	16870	5146	8000	50	1064	163000	100	60	95	100	62	56
	STD	0	0	0	1	0	0	0	0	0	0	0	0	180027	20841	1694	7261	739	2401	11	236	27500	21	12	19	18	10	16
CAN/SU	SUM	33	20	33	82	27	23	14	30	5	0	3	21	6174846	528590	15076	16870	9517	19879	27	340	302755	1327	379	130	490	230	44
	COUNT	33	20	33	33	27	23	14	30	6	0	3	21	33	23	16	1	19	4	6	5	8	24	18	2	21	5	6
	AVG	1	1	1	2	1	1	1	1	1		1	1	187117	22982	942	16870	501	4970	5	68	37844	55	21	65	23	46	7
	MIN	1	1	1	2	1	1	1	1	0		1	1	4200	10	6	16870	3	3500	1	1	1800	35	5	60	1	37	3
	MAX	1	1	1	4	1	1	1	1	1		1	1	2072738	155000	8000	16870	3843	8000	12	143	163000	90	56	70	45	62	13
	STD	0	0	0	1	0	0	0	0	0		0	0	368552	34673	1860	0	969	1792	4	60	53131	14	14	5	15	9	4
CAN/WSU	SUM	159	101	156	345	146	115	66	102	23	1	66	86	4324483	723414	50416	2945	10867	11540	51	2097	328346	8510	1693	227	1572	120	273
	COUNT	159	102	157	159	146	115	67	102	24	1	67	87	156	112	106	2	68	4	12	22	44	120	108	4	81	2	14
	AVG	1	1	1	2	1	1	1	1	1	1	1	1	27721	6459	476	1473	160	2885	5	95	7462	71	16	57	19	60	19
	MIN	1	0	0	1	1	1	0	1	0	1	0	0	500	1	2	1245	1	1000	0	0	0	20	1	39	0	60	1
	MAX	1	1	1	5	1	1	1	1	1	1	1	1	592000	111770	16707	1700	5146	7150	50	1064	95223	100	60	95	100	60	56
	STD	0	0	0	1	0	0	0	0	0	0	0	0	78077	15170	1659	228	642	2479	14	260	15443	21	11	22	18	0	18
MAR	SUM	10	5	10	23	8	7	2	10	1	0	2	5	64340	10674	969	1700	42	0	0	25	0	671	86	0	96	48	0
	COUNT	10	5	10	10	8	7	2	10	1	0	2	5	10	7	7	1	2	0	1	1	0	9	6	0	4	1	0
	AVG	1	1	1	2	1	1	1	1	1		1	1	6434	1525	138	1700	21		0	25		75	14		24	48	
	MIN	1	1	1	2	1	1	1	1	1		1	1	2400	819	40	1700	2		0	25		25	2		1	48	
	MAX	1	1	1	5	1	1	1	1	1		1	1	15000	3200	290	1700	40		0	25		100	40		50	48	
	STD	0	0	0	1	0	0	0	0	0		0	0	3624	874	94	0	19		0	0		25	14		21	0	
QUE	SUM	25	19	24	.53	20	14	14	20	4	0	7	13	263515	35650	2281	0	113	0	5	742	30645	1190	289	39	216	0	166
	COUNT	25	19	24	25	20	14	14	20	4	0	7	13	23	13	14	0	8	0	4	3	6	18	16	1	12	0	4
	AVG	1	1	1	2	1	1	1	1	1		1	1	11457	2742	163	ERR	14		1	247	5108	66	18	39	18		42
	MIN	1	1	1	1	1	1	1	1	1		1	1	1400	600	9	ERR	3		1	1	632	22	2	39	0		30
	MAX	1	1	1	3	1	1	1	1	1		1	1	58000	12430	660	ERR	60		2	739	13752	100	58	39	40		56
	STD	0	0	0	0	0	0	0	0	0		0	0	14136	2922	160	ERR	18		0	348	4666	25	15	0	11		9
ONT	SUM	94	55	92	222	86	68	41	53	19	1	46	51	8220500	690786	44003	1245	17352	13709	80	1162	363135	4584	881	248	1374	199	109
	COUNT	94	56	93	94	86	68	42	53	21	1	47	52	93	60	50	1	44	4	12	11	31	70	59	4	54	4	11
	AVG	1	1	1	2	1	1	1	1	1	1	1	1	88392	11513	880	1245	394	3427	7	106	11714	65	15	62	25	50	10
	MIN	1	0	0	1	1	1	0	1	0	1	0	0	500	1	2	1245	1	1000	0	0	0	20	1	43	1	37	1
	MAX	1	1	1	5	1	1	1	1	1	1	1	1	2072738	111770	16707	1245	5146	7150	50	1064	95223	100	60	95	100	62	37
	STD	0	0	0	1	0	0	0	0	0	0	0	0	243054	21777	2582	0	999	2383	13	303	22136	22	11	20	20	11	12

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Table B.1 - cont'd

SECTION I

		QUE. 1	QUE. 2	QUE. 3	QUE. 4	QUESTION 5						QUE. 6A	QUE. 6B	QUE. 7	QUESTION 8 (NO S OF ACCOUNTS)								QUESTION 9 (% OF EFFLUENT FLOW)					
						1	2	3	4	5	6			(POP.)	DOM	COM	CO+DOM	IND	CO+IND	MUN	OTHER	TOTAL	DOM	COM	CO+DOM	IND	CO+IND	OTHER
ONT/SU	SUM	15	6	15	44	11	11	6	13	2	0	2	9	4850799	198554	8690	0	7627	3809	24	2	118261	539	137	60	295	139	31
	COUNT	15	6	15	15	11	11	6	13	3	0	2	9	15	8	4	0	7	1	5	1	3	11	7	1	9	3	4
	AVG	1	1	1	3	1	1	1	1	1		1	1	323360	24819	2173	ERR	1090	3809	5	2	39420	49	20	60	33	46	8
	MIN	1	1	1	2	1	1	1	1	0		1	1	4667	10	6	ERR	8	3809	1	2	2918	35	8	60	15	37	3
	MAX	1	1	1	4	1	1	1	1	1		1	1	2072738	71600	8000	ERR	3843	3809	12	2	75443	65	44	60	45	62	13
	STD	0	0	0	1	0	0	0	0	0		0	0	492192	25596	3372	ERR	1350	0	4	0	29652	11	12	0	10	11	4
ONT/NSU	SUM	79	49	77	178	75	57	35	40	17	1	44	43	3370101	492232	35313	1245	9725	9900	56	1160	244874	4046	744	188	1079	60	79
	COUNT	79	50	78	79	75	57	36	40	18	1	45	44	78	52	46	1	37	3	7	19	28	59	52	3	45	1	7
	AVG	1	1	1	2	1	1	1	1	1	1	1	1	43206	9466	768	1245	263	3300	8	116	8746	69	14	63	24	60	11
	MIN	1	0	0	1	1	1	0	1	0	1	0	0	500	1	2	1245	1	1000	0	0	0	20	1	43	1	60	1
	MAX	1	1	1	5	1	1	1	1	1	1	1	1	592000	111770	16707	1245	5146	7150	59	1064	95223	100	60	95	100	60	37
	STD	0	0	0	1	0	0	0	0	0	0	0	0	105782	20370	2470	0	856	2740	17	316	19901	22	11	23	21	0	14
PRA	SUM	40	25	40	82	37	29	16	37	4	0	2	22	1394427	365179	11294	0	1276	16070	3	439	199608	2221	576	0	218	43	42
	COUNT	40	25	40	40	37	29	16	37	4	0	2	22	40	35	32	0	23	3	1	9	10	31	30	0	24	1	5
	AVG	1	1	1	2	1	1	1	1	1		1	1	34861	10434	353		55	5357	3	49	19961	72	19		9	43	8
	MIN	1	1	1	2	1	1	1	1	1		1	1	3000	800	50		3	3500	3	1	1760	40	5		1	43	3
	MAX	1	1	1	4	1	1	1	1	1		1	1	600000	155000	1160		300	8000	3	143	163000	94	56		37	43	17
	STD	0	0	0	0	0	0	0	0	0		0	0	98024	27200	302		75	1919	0	50	47757	14	11		8	0	5
PRA/SU	SUM	14	10	14	30	12	9	6	14	3	0	0	10	1217247	325062	5903	0	708	16070	3	338	184494	632	217	0	95	43	13
	COUNT	14	10	14	14	12	9	6	14	3	0	0	10	14	13	10	0	10	3	1	4	5	10	9	0	9	1	2
	AVG	1	1	1	2	1	1	1	1	1			1	86946	25005	590		71	5357	3	85	36899	63	24		11	43	6
	MIN	1	1	1	2	1	1	1	1	1			1	4337	1183	100		3	3500	3	1	1800	40	5		1	43	3
	MAX	1	1	1	4	1	1	1	1	1			1	600000	155000	1160		300	8000	3	143	163000	90	56		37	43	10
	STD	0	0	0	1	0	0	0	0	0			0	152501	40657	398		94	1919	0	56	63141	15	16		11	0	4
PRA/NSU	SUM	26	15	26	52	25	20	10	23	1	0	2	12	177180	40117	5391	0	568	0	0	101	15114	1589	359	0	123	0	29
	COUNT	26	15	25	26	25	20	10	23	1	0	2	12	26	22	22	0	13	0	0	5	5	21	21	0	15	0	3
	AVG	1	1	1	2	1	1	1	1	1		1	1	6815	1824	245		44			20	3023	76	17		8		19
	MIN	1	1	1	2	1	1	1	1	1		1	1	3000	800	50		10			10	1760	50	5		1		5
	MAX	1	1	1	2	1	1	1	1	1		1	1	17000	4035	590		198			40	4515	94	33		20		17
	STD	0	0	0	0	0	0	0	0	0		0	0	3534	818	152		54			11	968	11	8		5		5
BCR	SUM	21	15	21	42	20	18	5	10	0	0	12	16	541547	148915	6845	16870	1577	1640	0	69	37713	1056	225	70	149	0	0
	COUNT	21	15	21	21	20	18	5	10	0	0	12	16	21	19	18	1	9	1	0	3	5	14	14	1	7	0	0
	AVG	1	1	1	2	1	1	1	1			1	1	25788	7838	380	16870	175	1640		23	7543	75	16	70	21		
	MIN	1	1	1	2	1	1	1	1			1	1	3500	783	30	16870	3	1640		1	899	50	3	70	1		
	MAX	1	1	1	2	1	1	1	1			1	1	170000	45942	1493	16870	1179	1640		59	14650	97	26	70	40		
	STD	0	0	0	0	0	0	0	0			0	0	39526	12002	396	0	358	0		26	5945	15	8	0	13		

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Table B.1 - cont'd

SECTION 1 (CONT'D) / SECTION 2

		QUE. 10A	QUESTION 10B (% TREATMENT BY TYPE) NIL	LAGO	PRIM	PR/P	SEC	SE/P	TER	OTH	QUESTION 10C (MIGD) DESIGN	AVE.	MAX.	QUE. 10D (SLUDGE) D	R	L	I	O
CAN	SUM	276	125	5175	1607	1374	3581	5111	415	435	1916	1559	2038	57	46	12	7	51
	COUNT	190	3	58	21	14	42	55	9	10	176	174	116	57	47	12	7	53
	AVG	1	42	89	77	98	85	93	46	44	11	9	18	1	1	1	1	1
	MIN	0	5	2	0	76	0	0	0	0	0	0	0	1	0	1	1	0
	MAX	14	70	100	100	100	100	100	100	100	326	347	727	1	1	1	1	1
	STD	2	27	28	38	6	30	21	47	47	34	32	75	0	0	0	0	0
CAN/SU	SUM	79	0	311	505	176	796	1490	20	2	1239	1046	1609	16	10	2	6	10
	COUNT	33	0	6	6	2	9	16	3	1	33	33	24	16	10	2	6	10
	AVG	2		52	84	88	88	93	7	2	38	32	67	1	1	1	1	1
	MIN	1		2	5	76	1	24	1	2	0	0	1	1	1	1	1	1
	MAX	14		100	100	100	100	100	19	2	326	347	727	1	1	1	1	1
	STD	3		48	35	12	31	18	8	0	63	63	154	0	0	0	0	0
CAN/NSU	SUM	197	125	4964	1102	1193	2785	3621	395	433	677	512	430	41	36	10	1	41
	COUNT	157	3	52	15	12	33	39	6	9	143	141	92	41	37	10	1	43
	AVG	1	42	94	73	100	84	93	66	48	5	4	5	1	1	1	1	1
	MIN	0	5	3	0	98	0	0	0	0	0	0	0	1	0	1	1	0
	MAX	14	70	100	100	100	100	100	100	100	180	150	30	1	1	1	1	1
	STD	1	27	21	39	1	30	22	47	47	16	13	7	0	0	0	0	0
MAR	SUM	22	0	200	100	0	295	100	0	200	10	8	9	3	7	1	0	0
	COUNT	10	0	2	1	0	3	1	0	2	10	9	6	3	7	1	0	0
	AVG	2		100	100		98	100		100	1	1	1	1	1	1		
	MIN	1		100	100		95	100		100	0	0	0	1	1	1		
	MAX	8		100	100		100	100		100	2	2	4	1	1	1		
	STD	2		0	0		2	0		0	1	1	1	0	0	0		
QUE	SUM	26	120	500	300	300	663	447	0	0	36	38	72	3	9	2	0	7
	COUNT	24	2	5	3	3	9	5	0	0	20	21	19	3	9	2	0	7
	AVG	1	60	100	100	100	74	89			2	2	4	1	1	1		1
	MIN	1	50	100	100	100	30	67			0	0	0	1	1	1		1
	MAX	2	70	100	100	100	100	100			11	10	20	1	1	1		1
	STD	0	10	0	0	0	30	14			3	2	4	0	0	0		0
ONT	SUM	162	0	1945	137	1074	728	4364	315	235	1440	1205	1333	34	21	8	5	20
	COUNT	93	0	24	6	11	11	47	8	8	88	88	55	34	22	8	5	21
	AVG	2		81	23	98	66	93	39	29	16	14	24	1	1	1	1	1
	MIN	0		2	0	76	0	0	0	0	0	0	0	1	0	1	1	0
	MAX	14		100	83	100	100	100	100	100	326	347	727	1	1	1	1	1
	STD	2		36	31	7	44	22	46	42	42	42	98	0	0	0	0	0

		QUESTION 11 (INDUSTRIAL PROBLEM RATING) 1	2	3	4	5	6	7	8	9	10	11	QUESTION 12 1	2	3	4	QUESTION 13 (mg/l) BOD	SS	PHOS	GO	GOA	GOM	PH-	PH+	QUESTION 14 1	2	3	4
CAN	SUM	198	172	185	210	162	164	151	179	131	136	136	105	34	17	18	29390	33283	3352	5860	2900	620	519.0	876.5	20	37	51	17
	COUNT	110	118	112	114	112	115	108	113	110	100	100	105	37	18	18	80	80	43	42	25	36	91.0	90.0	20	36	51	17
	AVG	2	2	2	2	1	1	1	2	1	1	1	1	1	1	1	367	416	78	140	116	17	5.7	9.7	1	1	1	1
	MIN	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	15	30	10	15	50	10	5.0	8.0	1	1	1	1
	MAX	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1200	1200	130	500	300	100	6.5	10.5	1	2	1	1
	STD	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	201	208	39	98	44	14	0.3	0.6	0	0	0	0
CAN/SU	SUM	67	58	56	65	54	53	54	53	41	49	49	32	9	10	0	14060	14700	1520	2540	1500	290	183.0	315.0	1	19	20	6
	COUNT	31	32	31	32	31	31	31	31	31	29	29	32	9	10	0	31	30	17	13	12	14	32.0	32.0	1	19	20	6
	AVG	2	2	2	2	2	2	2	2	1	2	2	1	1	1		454	490	89	195	125	21	5.7	9.8	1	1	1	1
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1		200	250	10	90	50	10	5.5	9.0	1	1	1	1
	MAX	3	3	3	3	3	3	3	3	3	3	3	1	1	1		1200	1200	100	500	300	100	6.5	10.5	1	1	1	1
	STD	1	1	1	1	1	1	1	1	1	1	1	0	0	0		271	281	29	150	60	22	0.3	0.5	0	0	0	0
CAN/NSU	SUM	131	134	129	145	108	111	107	126	90	89	87	73	25	7	18	15330	18583	1832	3320	1400	330	336.0	561.5	17	18	31	11
	COUNT	79	86	81	82	81	84	77	82	79	71	71	73	28	8	18	49	50	26	29	13	22	59.0	58.0	19	17	31	11
	AVG	2	2	2	2	1	1	1	2	1	1	1	1	1	1	1	313	372	70	114	108	15	5.7	9.7	1	1	1	1
	MIN	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	15	30	10	15	100	15	5.0	8.0	1	1	1	1
	MAX	3	3	3	3	3	3	3	3	2	3	3	1	1	1	1	500	600	130	200	150	15	6.5	10.5	1	2	1	1
	STD	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	109	130	43	42	18	0	0.3	0.6	0	0	0	0
MAR	SUM	8	4	6	6	3	4	5	3	2	2	2	3	1	0	1	600	700	0	100	0	0	28.5	46.5	2	0	2	0
	COUNT	3	3	3	3	3	3	3	2	2	2	2	3	1	0	1	2	2	0	1	0	0	5.0	5.0	2	0	2	0
	AVG	3	1	2	2	1	1	2	2	1	1	1	1	1		1	300	350		100			5.7	9.3	1		1	
	MIN	2	1	2	2	1	1	1	1	1	1	1	1	1		1	300	350		100			5.5	8.5	1		1	
	MAX	3	2	2	2	1	2	2	2	1	1	1	1	1		1	300	350		100			6.0	9.5	1		1	
	STD	0	0	0	0	0	0	0	1	0	0	0	0	0		0	0	0		0			0.2	0.4	0		0	
QUE	SUM	21	21	22	21	18	17	16	20	16	14	11	9	4	1	4	165	530	700	250	300	90	44.0	76.0	2	2	6	1
	COUNT	11	12	12	12	12	12	11	12	12	11	10	9	4	1	4	2	2	7	2	2	6	8.0	8.0	2	2	6	1
	AVG	2	2	2	2	2	1	1	2	1	1	1	1	1	1	1	83	265	100	125	150	15	5.5	9.5	1	1	1	1
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15	30	100	100	150	15	5.5	9.5	1	1	1	1
	MAX	3	3	3	3	2	3	3	3	2	3	2	1	1	1	1	150	500	100	150	150	15	5.5	9.5	1	1	1	1
	STD	1	1	1	1	1	1	1	1	0	1	0	0	0	0	0	68	235	0	25	0	0	0.0	0.0	0	0	0	0
ONT	SUM	108	103	109	113	87	92	88	102	74	74	82	67	12	13	5	19605	22523	2542	2645	2300	430	336.0	563.5	10	27	31	9
	COUNT	64	68	66	67	65	66	61	66	63	58	59	67	15	14	5	58	58	34	23	22	29	58.0	57.0	10	28	31	9
	AVG	2	2	2	2	1	1	1	2	1	1	1	1	1	1	1	338	388	75	115	105	15	5.8	9.9	1	1	1	1
	MIN	1	1	1	1	1	1	0	1	1	1	1	1	0.	0	1	45	63	10	15	50	10	5.5	8.0	1	1	1	1
	MAX	3	3	3	3	2	2	3	3	2	3	3	1	1	1	1	500	600	130	200	150	15	6.5	10.5	1	2	1	1
	STD	1	1	1	1	0	0	1	1	0	0	1	0	0	0	0	91	114	41	41	21	1	0.3	0.6	0	0	0	0

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Table B.1 - cont'd

SECTION 1 (CONT'D)

		QUE.	QUESTION 10B (% TREATMENT BY TYPE)								QUESTION 10C (MIGD)			QUE. 10D (SLUDGE)				
		10A	NIL	LAGO	PRIM	PR/P	SEC	SE/P	TER	OTH	DESIGN	AVE.	MAX.	D	B	L	I	O
ONT/SU	SUM	59	0	106	5	176	1	1190	20	2	867	774	1019	9	5	1	5	2
	COUNT	15	0	3	1	2	1	13	3	1	15	15	8	9	5	1	5	2
	AVG	4		35	5	88	1	92	7	2	58	52	127	1	1	1	1	1
	MIN	1		2	5	76	1	24	1	2	1	1	1	1	1	1	1	1
	MAX	14		100	5	100	1	100	18	2	326	347	727	1	1	1	1	1
	STD	4		46	0	12	0	20	8	0	78	82	230	0	0	0	0	0
ONT/NSU	SUM	103	0	1839	132	898	727	3174	295	233	573	431	315	25	16	7	0	18
	COUNT	78	0	21	5	9	10	34	5	7	73	73	47	25	17	7	0	19
	AVG	1		88	26	100	73	93	59	33	8	6	7	1	1	1		1
	MIN	0		3	0	98	0	0	0	0	0	0	0	1	0	1		0
	MAX	14		100	93	100	100	100	100	100	180	150	30	1	1	1		1
	STD	2		29	32	1	40	23	48	43	22	18	8	0	0	0		0
PRA	SUM	43	0	2030	575	0	1095	200	0	0	382	274	572	15	6	1	1	14
	COUNT	40	0	22	6	0	11	2	0	0	39	38	24	15	6	1	1	14
	AVG	1		92	96		100	100			10	7	24	1	1	1	1	1
	MIN	0		5	75		95	100			0	0	0	1	1	1	1	1
	MAX	3		100	100		100	100			170	117	305	1	1	1	1	1
	STD	0		25	9		1	0			30	22	67	0	0	0	0	0
PRA/SU	SUM	16	0	205	300	0	695	200	0	0	352	256	563	6	3	1	1	7
	COUNT	14	0	3	3	0	7	2	0	0	14	14	13	6	3	1	1	7
	AVG	1		68	100		99	100			25	18	43	1	1	1	1	1
	MIN	1		5	100		95	100			0	0	1	1	1	1	1	1
	MAX	3		100	100		100	100			170	117	305	1	1	1	1	1
	STD	1		45	0		2	0			46	33	86	0	0	0	0	0
PRA/NSU	SUM	27	0	1825	275	0	400	0	0	0	30	18	10	9	3	0	0	7
	COUNT	26	0	19	3	0	4	0	0	0	25	24	11	9	3	0	0	7
	AVG	1		96	92		100				1	1	1	1	1			1
	MIN	0		25	75		100				0	0	0	1	1			1
	MAX	2		100	100		100				12	6	2	1	1			1
	STD	0		17	12		0				2	1	1	0	0			0
BCR	SUM	21	5	300	495	0	800	0	100	0	45	31	49	2	2	0	1	9
	COUNT	21	1	3	5	0	8	0	1	0	17	16	10	2	2	0	1	9
	AVG	1	5	100	99		100		100		3	2	5	1	1		1	1
	MIN	0	5	100	95		100		100		0	0	0	1	1		1	1
	MAX	2	5	100	100		100		100		13	9	24	1	1		1	1
	STD	1	0	0	2		0		0		3	2	7	0	0		0	0

SECTION 2

		QUESTION 11 (INDUSTRIAL PROBLEM RATINGS)											QUESTION 12			
		1	2	3	4	5	6	7	8	9	10	11	1	2	3	4
ONT/SU	SUM	31	26	28	27	24	25	26	24	21	21	24	15	2	8	0
	COUNT	15	15	15	15	15	15	15	15	15	14	14	15	2	8	0
	AVG	2	2	2	2	2	2	2	2	1	2	2	1	1	1	
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	MAX	3	3	3	2	2	2	2	3	2	2	3	1	1	1	
	STD	0	1	0	0	0	0	0	1	0	1	1	0	0	0	
ONT/NSU	SUM	77	77	81	86	63	67	62	78	53	53	58	52	10	5	5
	COUNT	49	53	51	52	50	51	46	51	48	44	45	52	13	6	5
	AVG	2	1	2	2	1	1	1	2	1	1	1	1	1	1	1
	MIN	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1
	MAX	3	2	3	3	2	2	3	3	2	3	3	1	1	1	1
	STD	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0
PRA	SUM	50	49	37	55	42	37	39	40	30	33	32	19	11	2	7
	COUNT	26	27	25	26	25	26	26	26	26	22	23	19	11	2	7
	AVG	2	2	1	2	2	1	2	2	1	2	1	1	1	1	1
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	MAX	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1
	STD	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0
PRA/SU	SUM	29	25	20	30	23	21	22	21	15	20	19	14	4	2	0
	COUNT	13	14	13	14	13	13	13	13	13	12	12	14	4	2	0
	AVG	2	2	2	2	2	2	2	2	1	2	2	1	1	1	
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
	MAX	3	3	2	3	2	3	3	3	3	3	3	1	1	1	
	STD	1	1	0	1	0	1	1	1	1	1	1	0	0	0	
PRA/NSU	SUM	21	24	17	25	19	16	17	19	15	13	13	5	7	0	7
	COUNT	13	13	12	12	12	13	13	13	13	10	11	5	7	0	7
	AVG	2	2	1	2	2	1	1	1	1	1	1	1	1		1
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1		1
	MAX	3	3	3	3	3	2	2	3	2	2	2	1	1		1
	STD	1	1	1	1	1	0	0	1	0	0	0	0	0		0
BCR	SUM	9	14	10	13	10	12	11	13	9	11	8	7	5	1	0
	COUNT	5	7	5	5	6	7	6	6	6	6	5	7	5	1	0
	AVG	2	2	2	3	2	2	2	2	1	2	2	1	1	1	
	MIN	1	1	1	2	1	1	1	1	1	1	1	1	1	1	
	MAX	3	3	3	3	3	3	3	3	2	3	2	1	1	1	
	STD	1	1	1	0	1	1	1	1	0	1	0	0	0	0	

		QUESTION 13 (mg/l)								QUESTION 14			
		BOD	SS	PHOS	GO	GOA	GOM	PH-	PH+	1	2	3	4
ONT/SU	SUM	5260	5950	1310	150	1050	175	88.5	153.5	0	12	10	3
	COUNT	14	14	14	1	10	12	15.0	15.0	0	12	10	3
	AVG	376	425	94	150	105	15	5.9	10.2		1	1	1
	MIN	300	250	10	150	50	10	5.5	9.5		1	1	1
	MAX	500	600	100	150	150	15	6.0	10.5		1	1	1
	STD	94	121	23	0	27	1	0.2	0.4		0	0	0
ONT/NSU	SUM	14345	16573	1232	2495	1250	255	247.5	410.0	10	17	21	6
	COUNT	44	44	20	22	12	17	43.0	42.0	10	16	21	6
	AVG	326	377	62	113	104	15	5.8	9.8	1	1	1	1
	MIN	45	63	10	15	100	15	5.5	8.0	1	1	1	1
	MAX	500	600	130	200	150	15	6.5	10.5	1	2	1	1
	STD	87	109	46	42	14	0	0.3	0.6	0	0	0	0
PRA	SUM	7720	7530	110	2165	300	100	83.5	143.0	3	6	7	5
	COUNT	15	14	2	11	1	1	15.0	15.0	3	6	7	5
	AVG	515	538	55	197	300	100	5.6	9.5	1	1	1	1
	MIN	20	30	10	25	300	100	5.5	9.0	1	1	1	1
	MAX	1200	1200	100	500	300	100	6.5	10.5	1	1	1	1
	STD	379	398	45	168	0	0	0.2	0.5	0	0	0	0
PRA/SU	SUM	7700	7500	110	2040	300	100	72.5	123.5	1	6	6	3
	COUNT	14	13	2	9	1	1	13.0	13.0	1	6	6	3
	AVG	550	577	55	227	300	100	5.6	9.5	1	1	1	1
	MIN	200	250	10	90	300	100	5.5	9.0	1	1	1	1
	MAX	1200	1200	100	500	300	100	6.5	10.0	1	1	1	1
	STD	368	387	45	171	0	0	0.3	0.4	0	0	0	0
PRA/NSU	SUM	20	30	0	125	0	0	11.0	19.5	2	0	1	2
	COUNT	1	1	0	2	0	0	2.0	2.0	2	0	1	2
	AVG	20	30		63			5.5	9.8	1		1	1
	MIN	20	30		25			5.5	9.0	1		1	1
	MAX	20	30		100			5.5	10.5	1		1	1
	STD	0	0		38			0.0	0.8	0		0	0
BCR	SUM	1300	2000	0	700	0	0	27.0	47.5	2	0	5	2
	COUNT	3	4	0	5	0	0	5.0	5.0	2	0	5	2
	AVG	433	500		140			5.4	9.5	1		1	1
	MIN	300	300		100			5.0	9.5	1		1	1
	MAX	500	600		150			5.5	9.5	1		1	1
	STD	94	122		20			0.2	0.0	0		0	0

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SECTION 2 (CONT'D)

		QUESTION 15				QUESTION 16A (# OF SAMPLES)					QUESTION 16B				QUESTION 17						QUE.	QUE.	QUE.	QUE.	QUESTION 22		QUESTION 23						
		1	2	3	4	GRAB	9-HR	24-HR	OTH.	TOT.	BOD	MET	TOX	PH	1	2	3	4	5	6	13	19	20	21	AVE.	MAX.	1	2	3	4	5	6	7
CAN	SUM	36	41	63	14	3938	2240	5581	26152	37911	103	56	34	58	64	24	11	10	28	5	4033	287	170	191450	23979	17900	60	28	28	4	12	2	9
	COUNT	37	41	63	15	39	11	29	9	52	28	30	24	29	64	24	11	10	28	5	57	33	6	70	6	4	60	30	28	4	12	2	9
	AVG	1	1	1	1	101	204	192	2906	729	4	2	1	2	1	1	1	1	1	1	71	9	28	2592	3997	4475	1	1	1	1	1	1	1
	MIN	0	1	1	0	3	5	3	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	50	50	1000	1	0	1	1	1	1	1
	MAX	1	1	1	1	580	1440	755	18000	18000	25	6	4	10	1	1	1	1	1	1	1817	63	163	100000	14500	12500	1	1	1	1	1	1	1
	STD	0	0	0	0	121	414	251	5494	2534	5	1	1	2	0	0	0	0	0	0	255	12	60	11852	5357	4661	0	0	0	0	0	0	0
CAN/SU	SUM	5	20	27	6	2040	782	3569	25902	32293	45	37	20	32	25	15	3	3	6	3	3832	237	168	27350	9429	17900	11	20	20	1	6	0	6
	COUNT	5	20	27	6	17	8	14	8	25	16	18	14	16	25	15	3	3	6	3	26	17	4	22	4	4	11	21	20	1	6	0	6
	AVG	1	1	1	1	120	98	255	3238	1292	3	2	1	2	1	1	1	1	1	1	147	14	42	1243	2357	4475	1	1	1	1	1		1
	MIN	1	1	1	1	8	5	10	1	10	1	1	1	1	1	1	1	1	1	1	1	1	1	50	250	1000	1	0	1	1	1		1
	MAX	1	1	1	1	580	509	755	18000	18000	7	6	4	6	1	1	1	1	1	1	1817	63	163	5000	7500	12500	1	1	1	1	1		1
	STD	0	0	0	0	147	156	291	5741	3538	2	1	1	1	0	0	0	0	0	0	363	15	70	1036	2981	4661	0	0	0	0	0		0
CAN/NSU	SUM	31	21	36	8	1898	1458	2012	250	5613	58	19	14	26	39	9	8	7	22	2	201	50	2	154100	14550	0	49	9	8	3	6	2	3
	COUNT	32	21	36	9	22	3	15	1	27	12	12	10	12	39	9	8	7	22	2	31	16	2	48	2	0	49	9	8	3	6	2	3
	AVG	1	1	1	1	86	486	134	250	208	5	2	1	2	1	1	1	1	1	1	6	3	1	3210	7275		1	1	1	1	1	1	1
	MIN	0	1	1	0	3	6	3	250	3	1	1	1	1	1	1	1	1	1	1	1	1	1	50	50		1	0	1	1	1	1	1
	MAX	1	1	1	1	300	1440	720	250	2364	25	3	3	10	1	1	1	1	1	1	36	15	1	100000	14500		1	1	1	1	1	1	1
	STD	0	0	0	0	95	675	190	0	455	7	1	1	2	0	0	0	0	0	0	8	3	0	14252	7225		0	0	0	0	0	0	0
MAR	SUM	4	1	1	0	0	0	0	0	0	0	0	0	0	2	0	1	1	2	0	4	1	0	1400	0	0	4	1	1	0	0	1	0
	COUNT	4	1	1	0	0	0	0	0	0	0	0	0	0	2	0	1	1	2	0	1	1	0	3	0	0	4	1	1	0	0	1	0
	AVG	1	1	1											1		1	1	1		4	1		467			1	1	1			1	
	MIN	1	1	1											1		1	1	1		4	1		200			1	1	1			1	
	MAX	1	1	1											1		1	1	1		4	1		1000			1	1	1			1	
	STD	0	0	0											0		0	0	0		0	0		377			0	0	0			0	
QUE	SUM	4	2	6	2	20	6	44	0	70	0	0	0	0	4	1	0	1	5	0	17	0	0	1500	0	0	6	0	0	0	2	0	1
	COUNT	4	2	6	2	2	1	4	0	4	0	0	0	0	4	1	0	1	5	0	4	0	0	5	0	0	6	1	0	0	2	0	1
	AVG	1	1	1	1	10	6	11		18					1	1		1	1		4			300			1	0			1		1
	MIN	1	1	1	1	5	6	3		3					1	1		1	1		1			300			1	0			1		1
	MAX	1	1	1	1	15	6	30		45					1	1		1	1		19			300			1	0			1		1
	STD	0	0	0	0	5	0	11		16					0	0		0	0		3			0			0	0			0		0
ONT	SUM	16	29	42	7	3593	2184	4429	26043	36254	94	45	26	49	39	18	6	4	16	4	3876	275	169	165900	16479	5400	39	18	19	3	6	1	5
	COUNT	17	29	42	8	29	8	21	7	37	25	25	20	25	39	18	6	4	16	4	39	27	5	49	5	3	39	19	19	3	6	1	5
	AVG	1	1	1	1	124	273	211	3721	980	4	2	1	2	1	1	1	1	1	1	99	10	34	3386	3296	1800	1	1	1	1	1	1	1
	MIN	0	1	1	0	3	10	8	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	50	50	1000	1	0	1	1	1	1	1
	MAX	1	1	1	1	580	1440	755	18000	18000	25	6	3	10	1	1	1	1	1	1	1817	63	163	100000	14500	2400	1	1	1	1	1	1	1
	STD	0	0	0	0	131	467	254	5984	2965	5	1	1	2	0	0	0	0	0	0	304	13	65	14074	5612	589	0	0	0	0	0	0	0

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SECTION 2 (CONT'D)

		QUESTION 15				QUESTION 16A (# OF SAMPLES)					QUESTION 16B			
		1	2	3	4	GRAB	8-HR	24-HR	OTH.	TOT.	BOD	MET	TOX	PH
ONT/SU	SUM	0	13	15	2	1726	732	2461	25798	30717	36	26	12	23
	COUNT	0	13	15	2	10	6	10	6	15	13	13	10	13
	AVG	ERR	1	1	1	173	122	246	4300	2048	3	2	1	2
	MIN	ERR	1	1	1	10	10	10	1	10	1	1	1	1
	MAX	ERR	1	1	1	580	500	755	18000	18000	7	6	3	6
	STD	ERR	0	0	0	169	174	295	6280	4405	2	2	1	1
ONT/NSU	SUM	16	16	27	5	1867	1452	1968	250	5537	58	19	14	26
	COUNT	17	16	27	6	19	2	11	1	22	12	12	10	12
	AVG	1	1	1	1	98	726	179	250	252	5	2	1	2
	MIN	0	1	1	0	3	12	8	250	3	1	1	1	1
	MAX	1	1	1	1	300	1440	720	250	2364	25	3	3	10
	STD	0	0	0	0	97	714	204	0	493	7	1	1	2
PRA	SUM	9	7	10	4	194	50	1000	104	1348	9	11	8	9
	COUNT	8	7	10	4	6	2	3	2	8	3	5	4	3
	AVG	1	1	1	1	32	25	333	52	169	3	2	2	3
	MIN	1	1	1	1	8	5	60	8	15	2	1	1	2
	MAX	1	1	1	1	96	45	750	96	750	4	4	4	4
	STD	0	0	0	0	32	20	299	44	234	1	1	1	1
PPA/SU	SUM	4	5	9	3	194	50	1000	104	1348	9	11	8	9
	COUNT	4	5	9	3	6	2	3	2	8	3	5	4	3
	AVG	1	1	1	1	32	25	333	52	169	3	2	2	3
	MIN	1	1	1	1	8	5	60	8	15	2	1	1	2
	MAX	1	1	1	1	96	45	750	96	750	4	4	4	4
	STD	0	0	0	0	32	20	299	44	234	1	1	1	1
PRA/NSU	SUM	4	2	1	1	0	0	0	0	0	0	0	0	0
	COUNT	4	2	1	1	0	0	0	0	0	0	0	0	0
	AVG	1	1	1	1									
	MIN	1	1	1	1									
	MAX	1	1	1	1									
	STD	0	0	0	0									
BCR	SUM	4	2	3	1	131	0	108	0	239	0	0	0	0
	COUNT	4	2	3	1	2	0	1	0	3	0	0	0	0
	AVG	1	1	1	1	66		108		80				
	MIN	1	1	1	1	11		108		11				
	MAX	1	1	1	1	120		108		120				
	STD	0	0	0	0	55		0		49				

		QUESTION 17						QUE.	QUE.	QUE.	QUE.	QUESTION 22		QUESTION 23						
		1	2	3	4	5	6	18	19	20	21	AVE.	MAX.	1	2	3	4	5	6	7
ONT/SU	SUM	12	10	1	0	2	2	3702	227	167	17300	1929	5400	2	13	13	0	3	0	4
	COUNT	12	10	1	0	2	2	15	13	3	12	3	3	2	13	13	0	3	0	4
	AVG	1	1	1		1	1	247	17	56	1442	643	1800	1	1	1		1		1
	MIN	1	1	1		1	1	2	1	1	300	250	1000	1	1	1		1		1
	MAX	1	1	1		1	1	1817	63	163	2000	1000	2400	1	1	1		1		1
	STD	0	0	0		0	0	453	16	76	588	307	589	0	0	0		0		0
ONT/NSU	SUM	27	8	5	4	14	2	174	48	2	148600	14550	0	37	5	6	3	3	1	1
	COUNT	27	8	5	4	14	2	24	14	2	37	2	0	37	6	6	3	3	1	1
	AVG	1	1	1	1	1	1	7	3	1	4016	7275		1	1	1	1	1	1	1
	MIN	1	1	1	1	1	1	1	1	1	50	50		1	0	1	1	1	1	1
	MAX	1	1	1	1	1	1	36	15	1	100000	14500		1	1	1	1	1	1	1
	STD	0	0	0	0	0	0	9	4	0	16143	7225		0	0	0	0	0	0	0
PRA	SUM	14	4	2	3	4	1	119	8	1	9150	7500	12500	9	6	6	1	4	0	2
	COUNT	14	4	2	3	4	1	9	3	1	10	1	1	9	6	6	1	4	0	2
	AVG	1	1	1	1	1	1	13	3	1	915	7500	12500	1	1	1	1	1		1
	MIN	1	1	1	1	1	1	1	1	1	50	7500	12500	1	1	1	1	1		1
	MAX	1	1	1	1	1	1	60	5	1	5000	7500	12500	1	1	1	1	1		1
	STD	0	0	0	0	0	0	19	2	0	1383	0	0	0	0	0	0	0		0
PPA/SU	SUM	11	4	1	2	3	1	119	8	1	9050	7500	12500	6	6	6	1	3	0	2
	COUNT	11	4	1	2	3	1	9	3	1	9	1	1	6	6	6	1	3	0	2
	AVG	1	1	1	1	1	1	13	3	1	1006	7500	12500	1	1	1	1	1		1
	MIN	1	1	1	1	1	1	1	1	1	50	7500	12500	1	1	1	1	1		1
	MAX	1	1	1	1	1	1	60	5	1	5000	7500	12500	1	1	1	1	1		1
	STD	0	0	0	0	0	0	19	2	0	1430	0	0	0	0	0	0	0		0
PRA/NSU	SUM	3	0	1	1	1	0	0	0	0	100	0	0	3	0	0	0	1	0	0
	COUNT	3	0	1	1	1	0	0	0	0	1	0	0	3	0	0	0	1	0	0
	AVG	1		1	1	1					100			1				1		
	MIN	1		1	1	1					100			1				1		
	MAX	1		1	1	1					100			1				1		
	STD	0		0	0	0					0			0				0		
BCR	SUM	5	1	1	1	1	0	17	3	0	3500	0	0	2	3	2	0	0	0	1
	COUNT	5	1	1	1	1	0	4	2	0	3	0	0	2	3	2	0	0	0	1
	AVG	1	1	1	1	1		4	2		1167			1	1	1				1
	MIN	1	1	1	1	1		1	1		500			1	1	1				1
	MAX	1	1	1	1	1		10	2		2000			1	1	1				1
	STD	0	0	0	0	0		3	1		624			0	0	0				0

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		SECTION 3 QUESTION 24									QUESTION 25A				QUE.	QUESTION 26			QUE.	SECTION 6 DATA IN SECTION	QUESTION 59 ($/YR)				QUEST. 59	QUE.
		1	2	3	4	5	6	7	8	9	1	2	3	4	25	1	2	3	27	3A? Y=1	1	2	3	4	($/YR)	60
CAN	SUM	11	29	8	5	89	20	17	32	2	7	89	3	1	159	86	35	8	196	33	$76,475,819	$112,674,236	$3,209,958	$221,291,486	$46,147,432	183
	COUNT	11	30	9	5	89	20	17	32	3	7	89	3	1	91	86	39	11	101	35	$137	$121	$68	$150	$57	168
	AVG	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	1	$559,218	$931,192	$47,205	$1,475,277	$809,604	1
	MIN	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	$1,000	$0	$0	$8,000	$0	1
	MAX	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	3	1	$21,740,000	$12,900,000	$756,000	$34,970,000	$12,900,000	2
	STD	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	$1,994,168	$2,090,912	$115,212	$4,060,676	$1,971,505	0
CAN/SU	SUM	0	5	1	2	26	2	12	30	1	2	27	1	0	46	1	31	1	14	33	$40,717,333	$76,907,213	$2,930,152	$123,162,640	$18,770,000	31
	COUNT	0	5	1	2	26	2	12	30	1	2	27	1	0	28	1	31	1	13	33	$23	$28	$19	$28	$7	31
	AVG	ERR	1	1	1	1	1	1	1	1	1	1	1		2	1	1	1	1	1	$1,770,319	$2,746,686	$149,955	$4,398,666	$2,681,429	1
	MIN	ERR	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	$42,177	$70,000	$0	$120,000	$0	1
	MAX	ERR	1	1	1	1	1	1	1	1	1	1	1		3	1	1	1	2	1	$21,740,000	$12,900,000	$756,000	$34,970,000	$12,900,000	1
	STD	ERR	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	0	0	$4,403,538	$3,516,451	$178,545	$6,937,370	$4,401,758	0
CAN/NSU	SUM	11	24	7	3	63	18	5	2	1	5	62	2	1	114	85	4	7	172	0	$35,758,486	$35,767,023	$379,816	$98,128,846	$27,377,432	152
	COUNT	11	25	8	3	63	18	5	2	2	5	62	2	1	63	85	8	10	88	2	$114	$93	$49	$122	$50	137
	AVG	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	2	0	$313,671	$384,592	$7,751	$804,335	$547,549	1
	MIN	1	0	0	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	0	$1,000	$0	$0	$8,000	$0	1
	MAX	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	3	0	$4,770,407	$6,243,996	$128,000	$27,310,000	$6,243,996	2
	STD	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	$714,531	$821,060	$22,107	$2,610,809	$1,075,674	0
MAR	SUM	1	1	0	0	4	0	0	2	0	0	4	0	0	7	4	2	0	11	1	$383,820	$623,544	$0	$1,619,138	$0	11
	COUNT	1	1	0	0	4	0	0	2	0	0	4	0	0	4	4	2	0	5	2	$9	$7	$2	$10	$0	10
	AVG	1	1			1			1			1			2	1	1		2	1	$98,202	$89,078	$0	$161,914		1
	MIN	1	1			1			1			1			1	1	1		1	0	$49,200	$12,000	$0	$54,800		1
	MAX	1	1			1			1			1			2	1	1		3	1	$257,000	$194,180	$0	$313,956		2
	STD	0	0			0			0			0			0	0	0		1	1	$67,051	$55,951	$0	$84,092		0
QUE	SUM	1	2	1	0	3	4	2	1	0	1	4	0	1	11	9	1	1	18	1	$839,724	$1,356,335	$41,300	$29,601,629	$143,000	19
	COUNT	1	2	1	0	3	4	2	1	0	1	4	0	1	4	9	1	1	9	1	$13	$10	$8	$15	$4	17
	AVG	1	1	1		1	1	1	1		1	1		1	3	1	1	1	2	1	$64,594	$135,634	$5,163	$1,973,442	$35,750	1
	MIN	1	1	1		1	1	1	1		1	1		1	2	1	1	1	1	1	$2,500	$0	$0	$8,000	$0	1
	MAX	1	1	1		1	1	1	1		1	1		1	3	1	1	1	3	1	$150,000	$925,000	$30,000	$27,310,000	$128,000	2
	STD	0	0	0		0	0	0	0		0	0		0	0	0	0	0	0	0	$41,841	$269,155	$9,567	$6,774,884	$53,611	0
ONT	SUM	6	21	2	3	50	4	9	14	2	5	48	2	0	82	51	16	5	105	15	$54,696,526	$88,640,789	$2,151,050	$149,688,947	$39,478,168	93
	COUNT	6	22	3	3	50	4	9	14	2	5	48	2	0	49	51	20	8	58	15	$68	$61	$42	$80	$39	84
	AVG	1	1	1	1	1	1	1	1	1	1	1	1		2	1	1	1	2	1	$804,361	$1,453,128	$51,215	$1,871,112	$1,012,261	1
	MIN	1	0	0	1	1	1	1	1	1	1	1	1		1	1	0	0	1	0	$1,000	$0	$0	$13,640	$0	1
	MAX	1	1	1	1	1	1	1	1	1	1	1	1		3	1	1	1	3	1	$21,740,000	$12,900,000	$330,000	$34,970,000	$12,900,000	2
	STD	0	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	1	0	$2,715,517	$2,669,631	$90,456	$4,428,231	$2,299,808	0

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Table B.1 - cont'd

		SECTION 3																			SECTION 6					
		QUESTION 24									QUESTION 25A				QUE.	QUESTION 26			QUE.	DATA IN SECTION	QUESTION 58 ($/YR)				QUEST. 59	QUE.
		1	2	3	4	5	6	7	8	9	1	2	3	4	25	1	2	3	27	3A? Y=1	1	2	3	4	($/YR)	60
ONT/SU	SUM	0	3	0	1	10	1	6	13	1	1	11	0	0	17	1	13	0	4	15	$29,960,437	$58,412,721	$1,808,734	$94,565,791	$18,255,000	13
	COUNT	0	3	0	1	10	1	6	13	1	1	11	0	0	11	1	13	0	4	15	$9	$12	$11	$13	$5	13
	AVG		1		1	1	1	1	1	1	1	1			2	1	1		1	1	$3,328,937	$4,867,727	$164,430	$7,274,292	$3,651,000	1
	MIN		1		1	1	1	1	1	1	1	1			1	1	1		1	1	$63,000	$303,000	$5,000	$374,000	$0	1
	MAX		1		1	1	1	1	1	1	1	1			2	1	1		1	1	$21,740,000	$12,900,000	$330,000	$34,370,000	$12,900,000	1
	STD		0		0	0	0	0	0	0	0	0			0	0	0		0	0	$6,545,564	$4,145,477	$109,896	$8,828,635	$4,879,437	0
ONT/NSU	SUM	6	18	2	2	40	3	3	1	1	4	37	2	0	65	50	3	5	101	0	$24,736,089	$30,229,067	$342,316	$55,123,156	$21,223,158	80
	COUNT	6	19	3	2	40	3	3	1	1	4	37	2	0	38	50	7	8	54	1	$59	$49	$31	$67	$34	71
	AVG	1	1	1	1	1	1	1	1	1	1	1	1		2	1	0	1	2	0	$419,256	$616,899	$11,042	$822,734	$624,211	1
	MIN	1	0	0	1	1	1	1	1	1	1	1	1		1	1	0	0	1	0	$1,000	$0	$0	$13,640	$0	1
	MAX	1	1	1	1	1	1	1	1	1	1	1	1		3	1	1	1	3	0	$4,770,407	$6,243,996	$128,000	$6,991,732	$6,243,996	2
	STD	0	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	1	0	$918,023	$1,053,124	$26,755	$1,235,604	$1,179,437	0
FRA	SUM	1	2	1	0	25	8	4	13	0	1	26	0	0	47	13	14	1	37	14	$13,208,197	$17,618,857	$261,618	$29,675,425	$165,580	37
	COUNT	1	2	1	0	25	8	4	13	0	1	26	0	0	26	13	14	1	22	14	$29	$27	$11	$27	$5	35
	AVG	1	1	1		1	1	1	1		1	1			2	1	1	1	2	1	$455,455	$652,550	$23,783	$1,099,090	$33,116	1
	MIN	1	1	1		1	1	1	1		1	1			1	1	1	1	1	1	$2,500	$1,400	$0	$22,710	$0	1
	MAX	1	1	1		1	1	1	1		1	1			3	1	1	1	3	1	$5,023,925	$6,966,261	$154,418	$12,144,504	$165,580	2
	STD	0	0	0		0	0	0	0		0	0			1	0	0	0	1	0	$976,850	$1,418,754	$44,335	$2,399,421	$66,232	0
PRA/SU	SUM	0	1	0	0	14	1	4	13	0	1	14	0	0	25	0	14	0	8	14	$10,309,626	$16,753,259	$260,418	$27,149,346	$0	14
	COUNT	0	1	0	0	14	1	4	13	0	1	14	0	0	14	0	14	0	8	14	$11	$12	$6	$12	$1	14
	AVG		1			1	1	1	1		1	1			2		1		1	1	$937,239	$1,396,105	$43,403	$2,262,446	$0	1
	MIN		1			1	1	1	1		1	1			1		1		1	1	$50,000	$70,000	$0	$120,000	$0	1
	MAX		1			1	1	1	1		1	1			3		1		1	1	$5,023,825	$6,966,261	$154,418	$12,144,504	$0	1
	STD		0			0	0	0	0		0	0			1		0		0	0	$1,445,836	$1,878,814	$52,504	$3,236,511	$0	0
PRA/NSU	SUM	1	1	1	0	11	7	0	0	0	0	12	0	0	22	13	0	1	29	0	$2,898,571	$865,598	$1,200	$2,526,079	$155,580	23
	COUNT	1	1	1	0	11	7	0	0	0	0	12	0	0	12	13	0	1	14	0	$18	$15	$5	$15	$4	21
	AVG	1	1	1		1	1					1			2	1		1	2		$161,032	$57,707	$240	$168,405	$41,395	1
	MIN	1	1	1		1	1					1			1	1		1	1		$2,500	$1,400	$0	$22,710	$0	1
	MAX	1	1	1		1	1					1			3	1		1	3		$703,143	$205,000	$1,000	$723,161	$165,580	2
	STD	0	0	0		0	0					0			1	0		0	1		$177,071	$55,310	$389	$184,666	$71,698	0
BCR	SUM	0	3	4	2	7	4	2	2	0	0	7	1	0	13	8	2	1	13	2	$5,874,352	$4,326,512	$756,000	$9,624,947	$6,360,684	21
	COUNT	0	3	4	2	7	4	2	2	1	0	7	1	0	8	8	2	1	6	2	$16	$14	$5	$16	$9	20
	AVG		1	1	1	1	1	1	1	0		1	1		2	1	1	1	2	1	$367,147	$309,037	$151,200	$601,559	$706,743	1
	MIN		1	1	1	1	1	1	1	0		1	1		1	1	1	1	2	1	$19,000	$1,440	$0	$25,000	$0	1
	MAX		1	1	1	1	1	1	1	0		1	1		3	1	1	1	3	1	$2,217,538	$1,194,000	$756,000	$2,219,538	$3,043,076	2
	STD		0	0	0	0	0	0	0	0		0	0		1	0	0	0	0	0	$582,568	$396,810	$302,400	$758,015	$950,641	0

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Table B.1 - cont'd

SECTION 3A

		QUE. 28 (YEAR)	QUE. 29 (MO.)	QUESTION 30					QUEST. 31A			QUESTION 31B					QUE. 32	QUE. 33	QUE. 34
				1	2	3	4	5	1	2	3	1	2	3	4	5			
CANADA	SUM	61194	363	4	20	13	21	5	28	3	3	5	0	2	4	3	244	41	44
	COUNT	31	21	4	20	13	21	5	28	3	3	5	0	2	4	3	20	28	29
	AVG	1974	17	1	1	1	1	1	1	1	1	1		1	1	1	12	1	2
	MIN	1953	1	1	1	1	1	1	1	1	1	1		1	1	1	2	1	1
	MAX	1987	48	1	1	1	1	1	1	1	1	1		1	1	1	24	2	2
	STD	8	12	0	0	0	0	0	0	0	0	0		0	0	0	6	0	0
ONTARIO	SUM	29567	259	1	11	5	10	1	10	3	3	3	0	1	2	2	164	18	20
	COUNT	15	12	1	11	5	10	1	10	3	3	3	0	1	2	2	13	14	15
	AVG	1971	22	1	1	1	1	1	1	1	1	1		1	1	1	13	1	1
	MIN	1953	1	1	1	1	1	1	1	1	1	1		1	1	1	6	1	1
	MAX	1981	48	1	1	1	1	1	1	1	1	1		1	1	1	24	2	2
	STD	7	12	0	0	0	0	0	0	0	0	0		0	0	0	5	0	0
PRAIRIES	SUM	25679	68	2	7	6	8	4	14	0	0	2	0	1	2	1	38	17	19
	COUNT	13	6	2	7	6	8	4	14	0	0	2	0	1	2	1	4	10	11
	AVG	1975	11	1	1	1	1	1	1			1		1	1	1	10	2	2
	MIN	1959	2	1	1	1	1	1	1			1		1	1	1	2	1	1
	MAX	1987	24	1	1	1	1	1	1			1		1	1	1	12	2	2
	STD	7	8	0	0	0	0	0	0			0		0	0	0	4	0	0

		QUESTION 35				QUESTION 36								QUESTION 37			QUESTION 38					QUESTION 39					QUE. 40
		1	2	3	4	1	2	3	4	5	6	7	8	1	2	3	1	2	3	4	5	1	2	3	4	5	
CANADA	SUM	21	2	9	2	59	47	60	53	31	30	40	3	25	5	1	26	6	2	6	0	5	1	0	28	0	46
	COUNT	21	2	9	2	29	29	29	29	29	28	29	3	25	5	1	26	6	2	6	0	5	1	0	28	0	32
	AVG	1	1	1	1	2.0	1.6	2.0	1.8	1.0	1.0	1.3	1	1	1	1	1	1	1	1		1	1		1		1.4
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1		1		1
	MAX	1	1	1	1	3	3	3	3	2	3	3	1	1	1	1	1	1	1	1		1	1		1		3
	STD	0	0	0	0	0.8	0.7	0.7	0.6	0.2	0.3	0.5	0	0	0	0	0	0	0	0		0	0		0		0.6
ONTARIO	SUM	8	1	7	1	32	26	33	27	17	15	20	1	11	2	1	8	6	1	3	0	0	1	0	14	0	20
	COUNT	8	1	7	1	15	15	15	15	15	15	15	1	11	2	1	8	6	1	3	0	0	1	0	14	0	15
	AVG	1	1	1	1	2.1	1.7	2.2	1.9	1.1	1	1.3	1	1	1	1	1	1	1	1			1		1		1.3
	MIN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			1		1		1
	MAX	1	1	1	1	3	3	3	3	2	1	3	1	1	1	1	1	1	1	1			1		1		2
	STD	0	0	0	0	0.8	0.7	0.7	0.5	0.3	0	0.5	0	0	0	0	0	0	0	0			0		0		0.4
PRAIRIES	SUM	10	0	2	1	22	18	22	21	11	12	16	2	11	2	0	14	0	1	3	0	3	0	0	12	0	19
	COUNT	10	0	2	1	11	11	11	11	11	10	11	2	11	2	0	14	0	1	3	0	3	0	0	12	0	13
	AVG	1		1	1	2	1.6	2	1.9	1	1.2	1.4	1	1	1		1		1	1		1			1		1.4
	MIN	1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1		1			1		1
	MAX	1		1	1	3	3	3	3	1	3	2	1	1	1		1		1	1		1			1		3
	STD	0		0	0	0.8	0.7	0.7	0.8	0	0.6	0.4	0	0	0		0		0	0		0			0		0.7

SECTION 3A

		QUESTION 41					QUE. 42 (# SAMPLES)			QUESTION 43 (TOT. # SAMPLES)					QUESTION 44					QUE. 45	QUE. 46	QUEST. 47 (REV./YR)	QUE. 48	QUESTION 49			Q.49 (QUARTERLY)			QUE. 50
		1	2	3	4	5	MAX.	MIN.	AVE.	GRAB	8 HR	24 HR	OTHER	TOTAL	1	2	3	4	5					MIN	FREQ	MAX	MIN	FREQ	MAX	
CANADA	SUM	16	4	7	2	6	1814	479	768	782	596	2962	1644	5984	2	26	12	7	2	400	347	$9,063,744	74	55	96	121	58	101	126	78
	COUNT	16	4	7	2	6	25	18	21	10	6	14	5	23	2	26	12	7	2	33	25	$24	32	19	20	19	19	20	19	18
	AVG	1	1	1	1	1	73	27	37	78	99	212	329	260	1	1	1	1	1	12	14	$377,656	2.31	3	5	6	3	5	7	4
	MIN	1	1	1	1	1	3	1	3	8	10	3	1	3	1	1	1	1	1	0	1	$2,800	1	1	2	2	1	2	3	1
	MAX	1	1	1	1	1	300	144	200	175	221	600	1000	1000	1	1	1	1	1	84	84	$2,704,547	5	8	8	8	8	8	8	28
	STD	0	0	0	0	0	82	41	48	56	77	209	387	271	0	0	0	0	0	19	20	$591,850	1.04	2	1	2	2	1	1	6
ONTARIO	SUM	2	3	3	2	5	1174	116	257	499	330	2001	1534	4363	0	12	6	6	2	256	233	$7,632,418	42	40	64	87	41	65	89	63
	COUNT	2	3	3	2	5	14	12	12	5	4	9	4	13	0	12	6	6	2	15	15	$15	15	13	13	13	13	13	13	10
	AVG	1	1	1	1	1	84	10	21	100	83	222	384	336		1	1	1	1	17	16	$508,828	2.8	3	5	7	3	5	7	6
	MIN	1	1	1	1	1	6	1	3	20	10	4	1	10		1	1	1	1	1	1	$2,800	1	1	2	4	1	2	4	1
	MAX	1	1	1	1	1	300	36	56	175	176	552	1000	1000		1	1	1	1	84	84	$2,704,547	5	7	7	8	6	7	8	28
	STD	0	0	0	0	0	84	10	18	58	65	207	415	305		0	0	0	0	21	21	$697,572	0.90	2	1	1	2	1	1	8
PRAIRIES	SUM	12	1	3	0	0	517	243	391	164	266	850	110	1390	2	11	3	1	0	121	91	$1,333,326	27	6	19	26	7	22	29	13
	COUNT	12	1	3	0	0	8	4	7	4	2	3	1	7	2	11	3	1	0	14	7	$7	13	4	5	5	4	5	5	6
	AVG	1	1	1			65	61	56	41	133	283	110	199	1	1	1	1		9	13	$190,475	2.07	2	4	5	2	4	6	2
	MIN	1	1	1			4	1	3	8	45	60	110	8	1	1	1	1		0	2	$7,500	1	1	2	2	1	3	3	1
	MAX	1	1	1			250	144	200	96	221	600	110	600	1	1	1	1		68	60	$720,000	4	3	5	8	3	6	8	5
	STD	0	0	0			83	59	69	36	88	230	0	196	0	0	0	0		18	19	$234,973	0.99	1	1	2	1	1	2	2

Table B.1 - cont'd

SECTION 4

		QUESTION 51 (MG/L)					QUESTION 52						Q.53(TREATMENT)			Q.53(COLLECT'N)			QUESTION 54				
		BOD	COD	SS	G&O	PHEN	1	2	3	4	5	6	CAP	O&M	OV.H	CAP	O&M	OV.H	1	2	3	4	5
CANADA	SUM	9850	1000	10500	1630	2	14	0	8	3	1	3	14	22	13	6	12	6	3	3	6	6	3
	COUNT	26	1	26	12	2	14	0	8	3	1	3	14	22	13	6	12	6	3	3	6	6	4
	AVG	379	1000	404	136	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.7
	MIN	200	1000	200	40	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
	MAX	1200	1000	1200	450	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	STD	199	0	194	99	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4
ONTARIO	SUM	4300	1000	5000	450	2	7	0	4	0	0	1	6	11	4	2	6	1	2	1	2	4	1
	COUNT	11	1	11	3	2	7	0	4	0	0	1	6	11	4	2	6	1	2	1	2	4	2
	AVG	391	1000	455	150	1	1		1			1	1	1	1	1	1	1	1	1	1	1	0.5
	MIN	300	1000	350	150	1	1		1			1	1	1	1	1	1	1	1	1	1	1	0
	MAX	500	1000	600	150	1	1		1			1	1	1	1	1	1	1	1	1	1	1	1
	STD	100	0	118	0	0	0		0			0	0	0	0	0	0	0	0	0	0	0	0.5
PRAIRIES	SUM	5250	0	4850	1080	0	4	0	3	3	1	2	7	8	8	3	4	4	0	1	4	2	2
	COUNT	14	0	13	8	0	4	0	3	3	1	2	7	8	8	3	4	4	0	1	4	2	2
	AVG	375		373	135		1		1	1	1	1	1	1	1	1	1	1		1	1	1	1
	MIN	200		200	40		1		1	1	1	1	1	1	1	1	1	1		1	1	1	1
	MAX	1200		1200	450		1		1	1	1	1	1	1	1	1	1	1		1	1	1	1
	STD	255		244	121		0		0	0	0	0	0	0	0	0	0	0		0	0	0	0

SECTION 5

		QUESTION 55										QUESTION 56											
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11	Q.57
CANADA	SUM	10	8	0	13	12	5	2	3	6	3	6	90	15	63	23	69	46	75	28	170	2	162
	COUNT	10	8	0	13	12	5	2	3	6	3	6	18	6	11	2	15	13	18	8	18	2	24
	AVG	1	1		1	1	1	1	1	1	1	1	5	3	6	12	5	4	4	4	9	1	7
	MIN	1	1		1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	1	0
	MAX	1	1		1	1	1	1	1	1	1	1	33	6	33	20	20	12	18	16	40	1	33
	STD	0	0		0	0	0	0	0	0	0	0	8	2	9	9	6	4	5	5	12	0	9
ONTARIO	SUM	6	5	0	6	6	3	1	1	1	0	1	68	11	56	3	43	37	45	25	101	0	83
	COUNT	6	5	0	6	6	3	1	1	1	0	1	9	3	8	1	8	7	9	6	9	0	10
	AVG	1	1		1	1	1	1	1	1		1	8	4	7	3	5	5	5	4	11		8
	MIN	1	1		1	1	1	1	1	1		1	1	2	1	3	1	1	1	1	1		0
	MAX	1	1		1	1	1	1	1	1		1	33	6	33	3	15	12	18	16	33		33
	STD	0	0		0	0	0	0	0	0		0	10	2	10	0	5	4	5	5	12		10
PRAIRIES	SUM	3	3	0	6	5	1	1	2	5	2	5	19	3	4	20	25	8	19	2	65	2	60
	COUNT	3	3	0	6	5	1	1	2	5	2	5	7	2	2	1	6	5	7	1	7	2	10
	AVG	1	1		1	1	1	1	1	1	1	1	3	2	2	20	4	2	3	2	9	1	6
	MIN	1	1		1	1	1	1	1	1	1	1	1	1	1	20	1	1	1	2	1	1	0
	MAX	1	1		1	1	1	1	1	1	1	1	10	2	3	20	20	2	10	2	40	1	30
	STD	0	0		0	0	0	0	0	0	0	0	3	1	1	0	7	0	3	0	13	0	9

See Notes on page B-29

TABLE B.2 - cont'd

NOTES:

1. Jurisdiction Code -

CAN	all Canada
MAR	P.E.I., N.B., N.S. and Nfld.
QUE	Quebec
ONT	Ontario
PRA	Man. Sask. and Alta.
BCR	British Columbia

2. Jurisdiction Subset Code

CAN	all respondents
CAN/SU	respondents with a surcharge program
CAN/NSU	respondents with no program (see note 5 for Sections 3A, 4 and 5)

3. Question Identifiers

   - cross reference against the municipal questionnaire (Figure B.1)

4. Summary Statistics

SUM	direct summation of individual entries
COUNT	count of non-blank entries
AUG	arithmetic mean of non-blank entries
MIN	smallest valued entry
MAX	largest valued entry
STD	standard diviation of non-blank entries

5. Table Entries

   - all raw data were coded in numeric form (numeric codes for categorical data are provided beside each data field on the questionnaire form, Figure B.1)
   - statistics are based on the raw numeric data

6. Sections 3A, 4 and 5

   - data in these sections pertain only to respondents with surcharge programs

APPENDIX C

MUNICIPAL INTERVIEW QUESTIONNAIRE FORM

INDUSTRY - SEWER USE EXTRA STRENGTH SURCHARGE QUESTIONNAIRE

General

1. Need a copy of the by-law and documentation of surcharge formula and rationale.

2. Need current rates for the formula (eg. $/kg excess BOD)

3. How are the unit rates in the surcharge formula determined? ____________________

   ____

Industry Specific Information

1. Company Name: ____________________
   Address: ____________________
   Phone Number: ____________________
   Contact: ____________________
   Contact's Title: ____________________

2. Industrial Sector (eg. meat processing, breweries, etc)

   ____

   Product Type: ____________________

3. Number of production employees: ____________________
   Gross Annual Sales: ____________________
   Units Produced/year: ____________________

4. Effluent Characteristics
   a) Effluent Volume: ____________________
   b) How is the flow monitored (ie. water consumption, wastewater flow, inferred from production etc.):

      ____

c) Description of Flow Variation: ______________________
____

d) Effluent quality (prior to pre-treatment), (list of paramaters and typical concentrations): ____________
____

e) Effluent quality (with pre-treatment), (list of parameters and typical concentrations): ____________
____

f) Other notable effluent characteristics (eg. Temp.):
____

5. Historical view of the industry's participation in the extra strength surcharge program.

a) How did the municipality/region become aware that the industry was an extra strength discharger?

choices:

1) Found out that they were exceeding the by-laws as a result of regular by-law monitoring: ______
____

2) Complaints. By whom? ______________________
When? ______________________________________
Nature of complaint: ______________________
How long did the complaints go on before action was taken? ______________________________

3) Problems at the WPCP. Nature of problem? ______
____
Duration of problem: ______________________
How did they associate this problem with the industry? ______________________________

4) Problems in the collection system
Nature of problem: ________________________
How did they assign this problem to the industry? ______________________________

5) Other? __________________________________

b) Did the municipality notify the industry prior to assigning a surcharge tax?______________________

c) Did the municipality allow the industry a period during which they could "clean-up"? ____________

d) How soon after the problem was the industry signed up for the extra strength program? ____________

e) How long has the industry been in the program? ____

____

6. User Charges

a) Annual cost to the firm? ____________

b) Idea of cost variation during the year? ____________

c) Are they assessed by the formula? ____________

d) Are they assessed based on a negotiated payment? ___

____

1) What is the payment? ____________

2) Rationale for arriving at the payment: ________

____

e) How often is the effluent monitored? ____________

1) Who is responsible for monitoring? ____________

____

2) Are QA/QC samples taken? ____________

7. Firm Response

a) Industry's perception of the surcharge:

User fee: ____________

Penalty: ____________

b) Was it an economic decision to pay the surcharge as apposed to installing a pre-treatment process:______

____

c) What alternatives were considered (eg. pre-treatment, modification of production process):

____

d) What was the outcome of considering these alternatives? ____________

e) Industry's future plans w.r.t. pre-treatment: ______

____

f) What problems, if any, does the industry have with the surcharge?

High surcharge cost: ______________________

Complexity of the charge: ______________________

Cost unfair: ______________________

8. Has there been any effect at the WPCP or in the collection system as a result of including this industry in the surcharge program? ______________________

APPENDIX D

COSTING INFORMATION SUMMARY

1.0 INDUSTRIAL PRE-TREATMENT

1.1 Treatment System Assumptions

Complete treatment systems were designed to facilitate treatment of a broad spectrum of industrial waste streams ranging from characteristically low volume - low strength (BOD) wastes to high volume - high strength (BOD) wastes and combinations thereof. The treatment systems were developed by combining appropriate unit processes capable of handling the desired flow as well as facilitating a BOD removal of 90 percent. Typically, industrial wastes streams are relatively low in suspended solids (SS) and therefore the majority of the treatment system configurations assumed here were not designed to specifically remove SS, however, due to the nature of these treatment systems, there would be some reduction of SS across the process train. A number of treatment process combinations were also included for a typical industrial waste streams with high SS. In these cases, specific treatment process units were selected to facilitate removal of SS.

The combinations of waste strengths and volumes used in the cost analysis are presented in Table 1. Flow sheets depiciting treatment trains relevant to each waste strength/volume combination are presented in Figures 1 to 9.

Screening was provided for all the treatment systems to prevent large objects from entering and disrupting plant equipment.

Since industrial waste stream flows will vary over a given time period, depending on the industrial process in question, it was necessary to include flow equalization as a unit process in most treatment systems to provide a continuous even flow through the treatment plant.

Table D.1

INDUSTRIAL WASTEWATER SPECIFICATIONS

USED FOR COST ANALYSIS

Volume (ML/day)	Waste Strength BOD_5 (mg/L)	SS (mg/L)	BOD Target Removal	Treatment System Selected
0.05	10 000	500	90	see Figure 1
0.5	10 000	500	90	see Figure 1
5.0	10 000	500	90	see Figure 1
0.05	5 000	500	90	see Figure 1
0.5	5 000	500	90	see Figure 1
5.0	5 000	500	90	see Figure 1
0.05	500	500	90	see Figure 2
0.05	500	500	60	see Figure 3
0.5	500	500	90	see Figure 4
0.05	500	500	90	see Figure 5
5.0	500	500	50	see Figure 5
5.0	500	500	50	see Figure 6
0.05	500	500	90	see Figure 7
0.5	500	500	90	see Figure 7
5.0	500	500	90	See Figure 7
0.05	500	5 000	90	See Figure 8
0.5	500	5 000	90	See Figure 9
5.0	500	5 000	90	See Figure 9

Industrial waste streams are often either excessively acidic or excessively basic thus, neutralization was added as a process step to prepare the wastewater for further treatment and subsequent discharge to a sanitary sewer system.

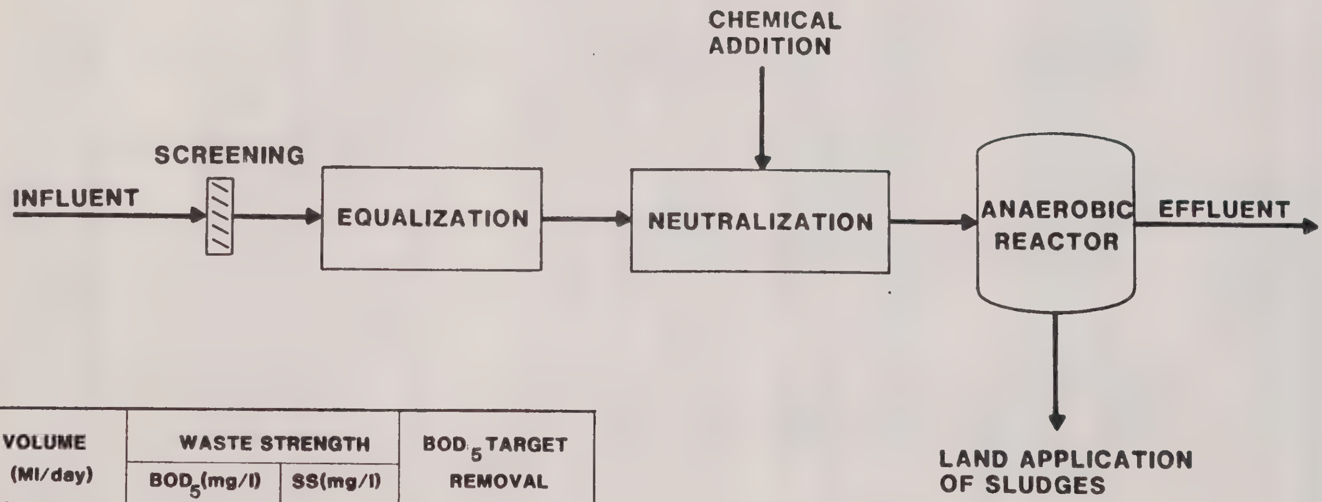
Primary clarification was selected for treatment of wastewaters with a low to medium organic loading and where only a 50 percent BOD5 removal rate was required. Ferric chloride addition was also included as a coagulant aid for the removal of phosphorus.

For the industrial waste streams with organic loadings comparable to those being received by municipal wastewater treatment plants, an activated sludge system with final sedimentation, commonly employed for treatment of municipal wastewater, was selected for removal of BOD and SS.

Anaerobic reactors were selected for waste streams with high organic loadings. Anaerobic reactors are favoured over conventional activated sludge (CAS) systems for high organic waste as they require much less energy for equivalent removal rates, resulting in lower operational costs. In addition, anaerobic reactors have the ability to provide energy return through methane formation.

Sequencing batch reactors (SBR) were selected for removal of BOD from low volume waste streams. The major advantage with SBRs is that they also provide clarification. CAS systems are not practical for BOD removal in low flow conditions as there are minimum size limitations on full scale operational clarifiers required for settling in CAS systems. External equalization basins were not included with SBR systems since the batch reactors intrinsically provide equalization.

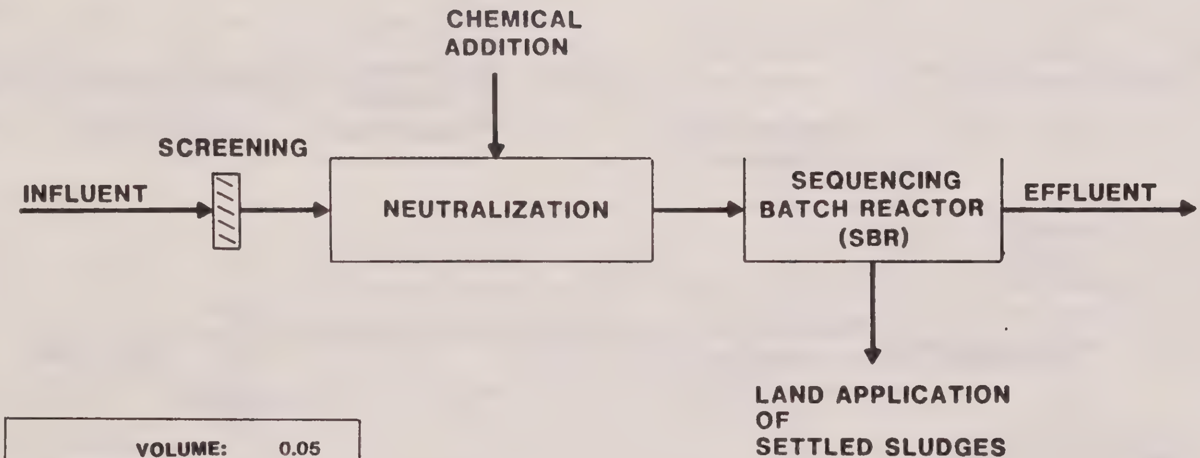
Dissolved air flotation (DAF) units and centrifuges equipped with polymer addition were selected for removal of high influent suspended solids (SS) (5000 mg/L). Experience has shown these process units to be and effective



VOLUME (Ml/day)	WASTE STRENGTH		BOD_5 TARGET REMOVAL
	BOD_5(mg/l)	SS(mg/l)	
0.05	10000	500	90
0.5	10000	500	90
5.0	10000	500	90
0.05	5000	500	90
0.5	5000	500	90
5.0	5000	500	90

Figure 1, FLOWSHEET "A"

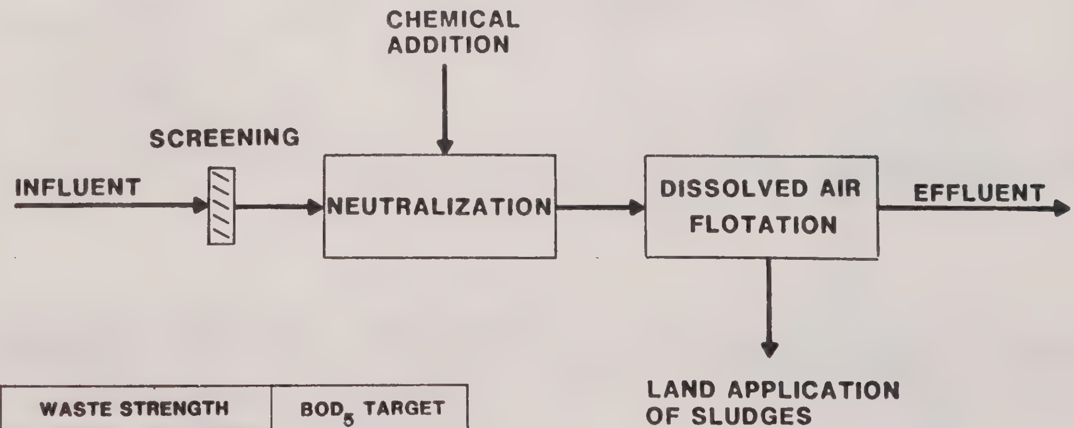
CANVIRO



VOLUME: (Ml/day)	0.05
WASTE STRENGTH: BOD_5(mg/l)	500
WASTE STRENGTH: SS(mg/l)	500
BOD_5 TARGET REMOVAL:	90

Figure 2, FLOWSHEET "B"

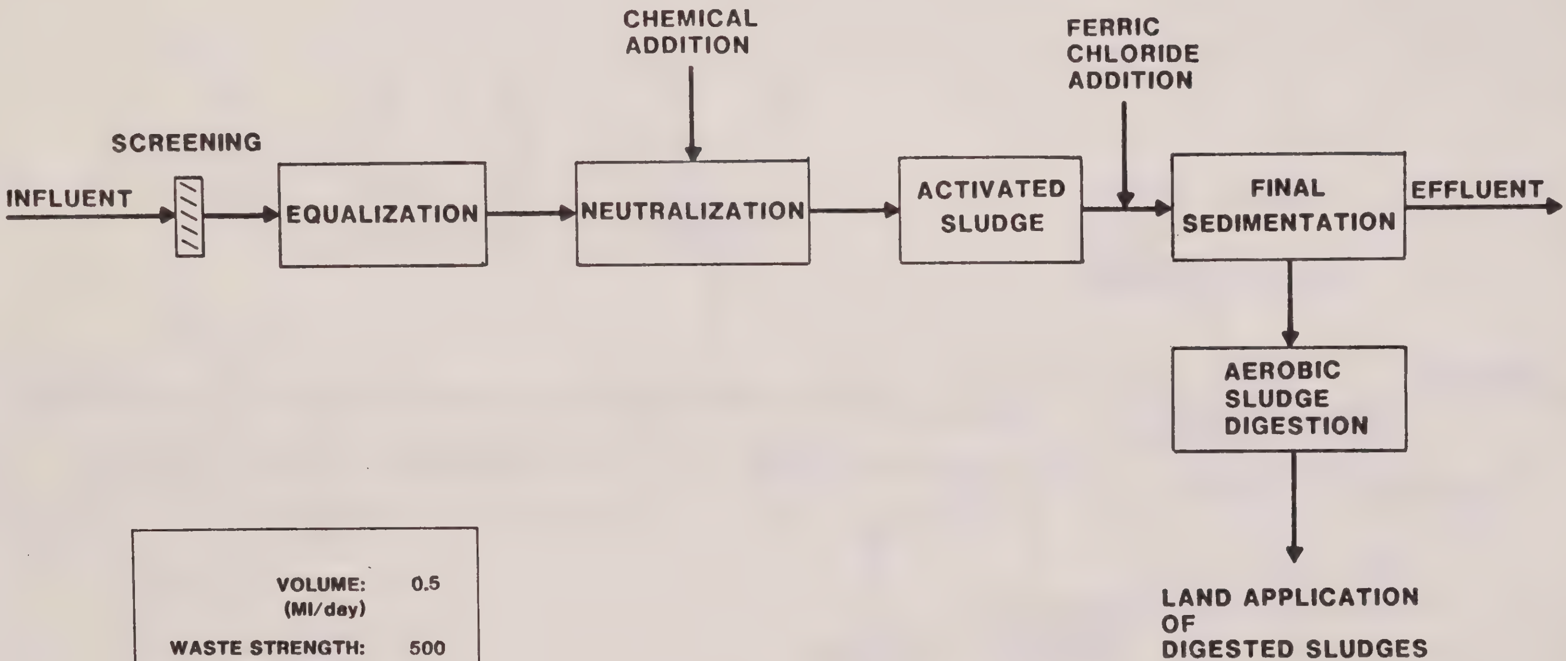
CANVIRO



VOLUME (Ml/day)	WASTE STRENGTH		BOD_5 TARGET REMOVAL
	BOD_5(mg/l)	SS(mg/l)	
0.05	500	500	60

Figure 3, FLOWSHEET "C"

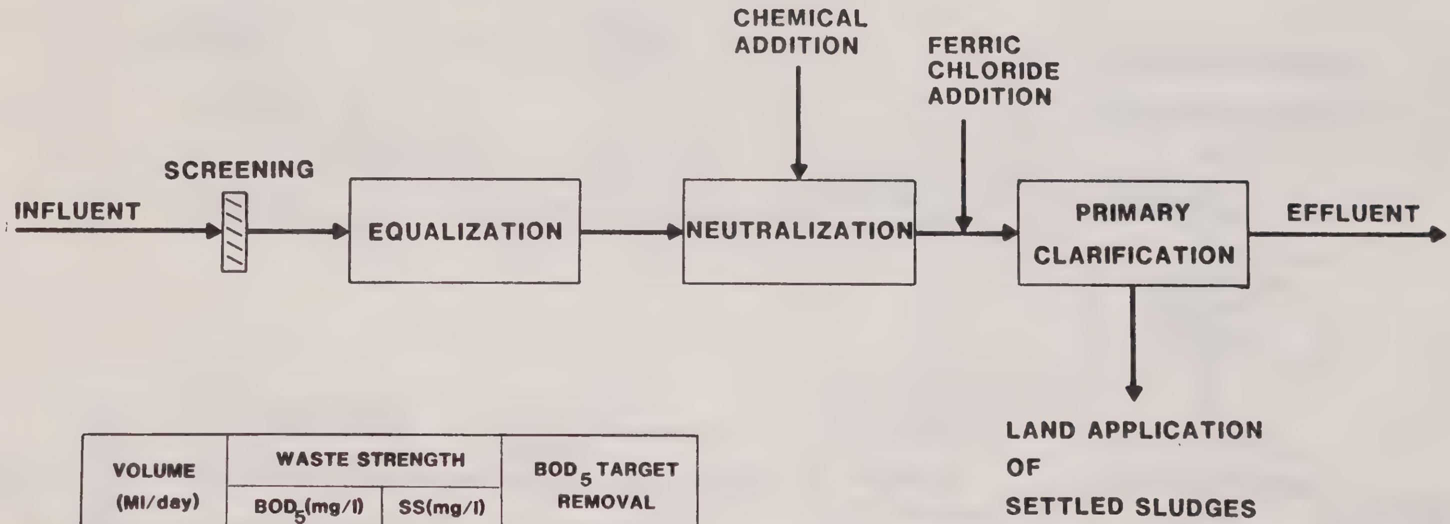
CANVIRO



VOLUME: (Ml/day)	0.5
WASTE STRENGTH: BOD_5(mg/l)	500
WASTE STRENGTH: SS(mg/l)	500
BOD_5 TARGET REMOVAL:	90

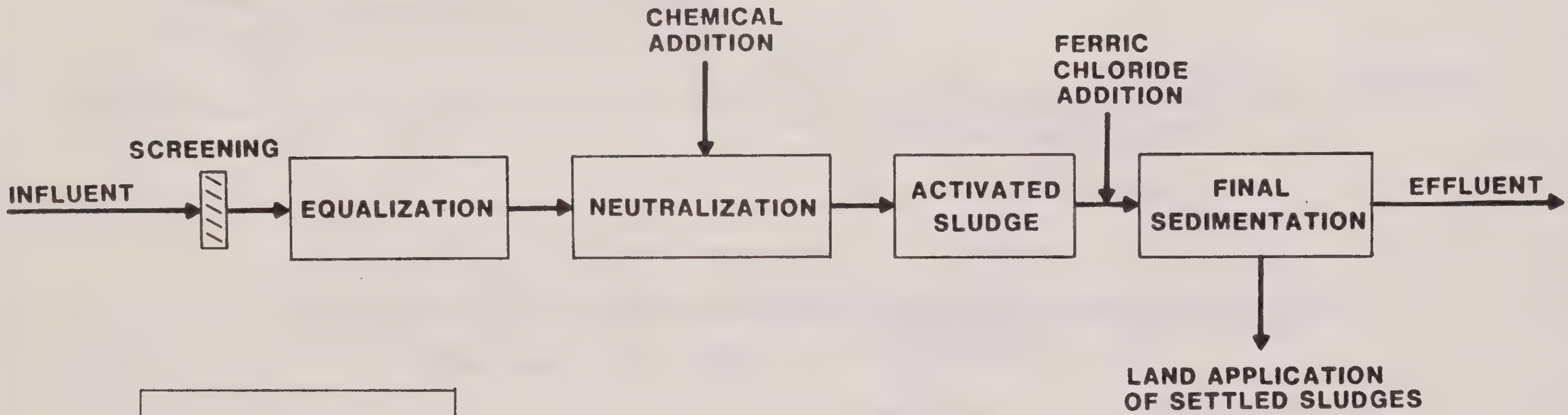
Figure 4, FLOWSHEET "D"

CANVIRO



VOLUME (Ml/day)	WASTE STRENGTH		BOD_5 TARGET REMOVAL
	BOD_5(mg/l)	SS(mg/l)	
0.05	500	500	90
5.0	500	500	50

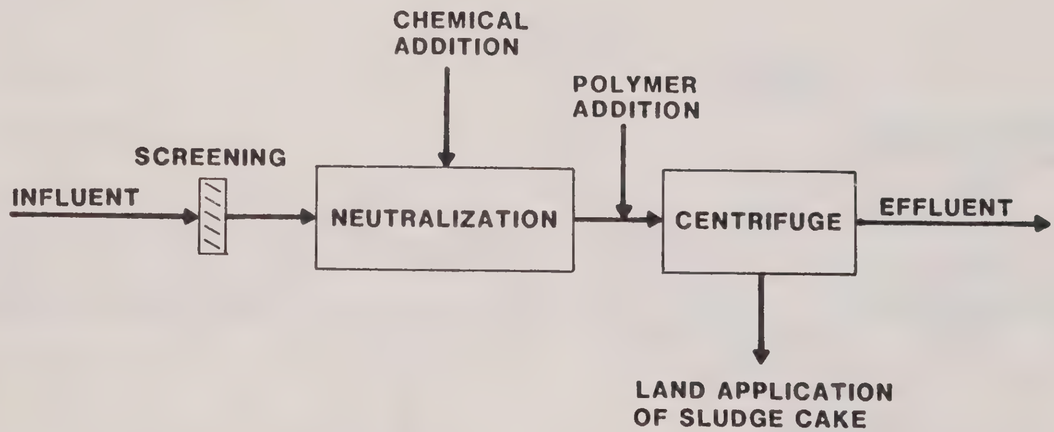
Figure 5, FLOWSHEET "E"



VOLUME: (Ml/day)	5.0
WASTE STRENGTH: BOD_5(mg/l)	500
WASTE STRENGTH: SS(mg/l)	500
BOD_5 TARGET REMOVAL:	50

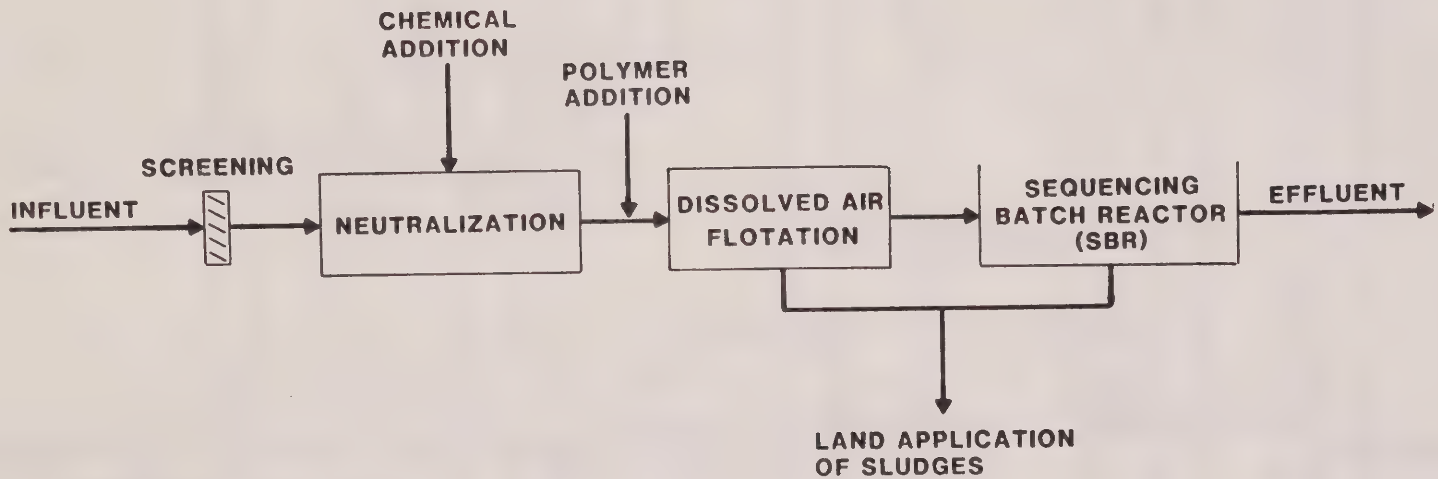
Figure 6, FLOWSHEET "F"

CANVIRO



VOLUME (Ml/day)	WASTE STRENGTH		BOD_5 TARGET REMOVAL
	BOD_5(mg/l)	SS(mg/l)	
0.05	500	500	90
0.5	500	600	90
5.0	500	500	90

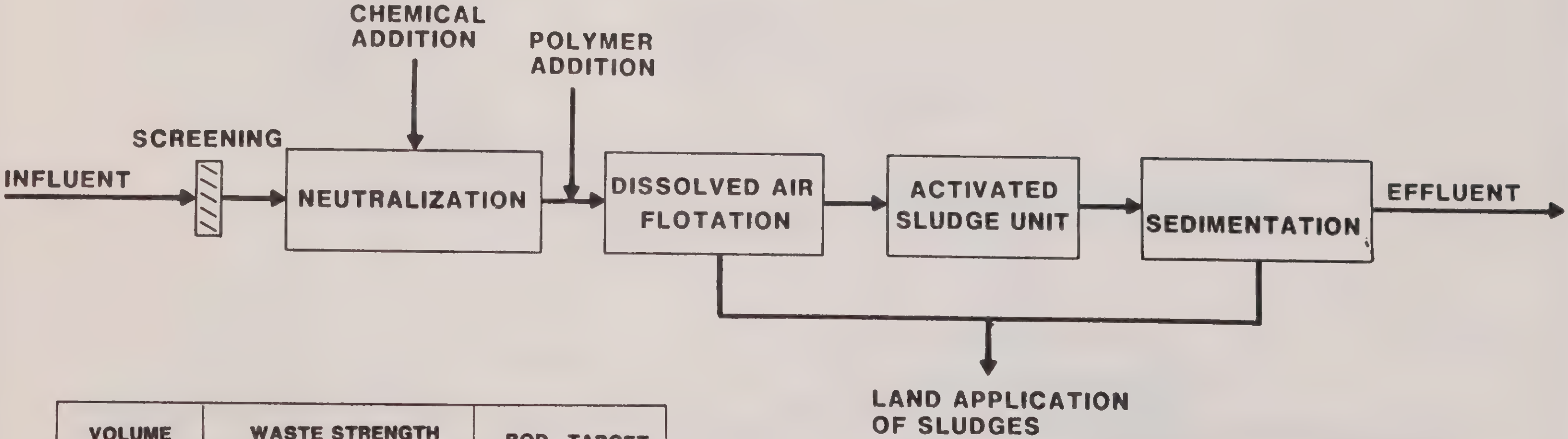
Figure 7, FLOWSHEET "G"



VOLUME: (Ml/day)	0.05
WASTE STRENGTH: BOD_5(mg/l)	5000
WASTE STRENGTH: SS(mg/l)	500
BOD_5 TARGET REMOVAL:	90

Figure 8, FLOWSHEET "H"

CANVIRO



VOLUME (Ml/day)	WASTE STRENGTH		BOD_5 TARGET REMOVAL
	BOD_5(mg/l)	SS(mg/l)	
5.0	5000	500	90
0.5	5000	500	90

Figure 9, FLOWSHEET "I"

CANVIRO

means of reducing high levels of SS. An additional benefit of the DAF units is its ability of effectively remove floatable oil and grease, typically found in wastewaters from the food processing industries.

Land application of sludges was selected as the universal sludge management option. Land application is the most commonly used and economically feasible method of sludge disposal. Where land application is precluded due to contamination of sludges, sludge disposal costs would be higher.

1.2 Industrial Pre-Treatment Capital Cost

The 1980 EPA document entitled: "Treatability Manual - Volume IV, Cost Estimating" was used to obtain capital costs for the following treatment processes:

- Screening
- Equalization
- Neutralization
- Primary clarification with ferric chloride addition
- Activated sludge treatment units
- Final sedimentation with ferric chloride addition
- Aerobic sludge digestion
- Dissolved air flotation
- Land application of sludges and sludge cake

The capital costs obtained from the EPA Treatability Manual were represented as 1979 US dollar values with the following cost component breakdown:

Cost Component	Assumed Value
Fixed capital investment (FCI):	
Direct costs	
o Purchased equipment and installation	PEI
o Instrumentation and controls	0.10 x PEI
o Piping	0.21 x PEI
o Electrical equipment and materials	0.13 x PEI
o Buildings	0.26 x PEI
o Yard improvements	0.07 x PEI
o Service facilities	0.41 x PEI
Indirect costs	
o Engineering and supervision	0.29 x PEI
o Construction expenses	0.32 x PEI
o Contractor's fees	0.07 x PEI
0 Contingency	0.27 x PEI
Direct plus Indirect Costs	3.13 x PEI
Working capital	0.47 x PEI
Total Fixed Capital Investments	3.60 x PEI

Total fixed capital investment is therefore 3.6 x PEI for each treatment process. For given flows, the PEI cost and total capital investment costs was obtained from cost curves provided in the Treatability Manual.

The following factors were used to update values to equivalent 1987 Canadian dollar costs:

1. 1979 US$ x 1.1715 = 1979 Can$

Ref: U.S./Canadian exchange rate, noon average from "Bank of Canada Review"

2. 1979 Can$ x (331.3/210.3) = 1987 Can$

Ref: Price index for expenditure on plant and equipment in the water systems industry from Statistics Canada, "Fixed Capital Flows and Stocks", Catalogue No. 13-568

(values in brackets are the price indices corresponding to 1987 and 1979)

Capital costs for anaerobic reactors were obtained from December, 1985 Agriculture Canada document entitled: "Final Report on the Evaluation of Single and Two Stage Anaerobic Digestion of Poultry Manure". The capital costs were represented as 1985 Canadian dollar values, and included the following cost components:

- o Purchased equipment and installation
- o Instrumentation and controls
- o Piping
- o Electrical and mechanical equipment and materials
- o Engineering design and supervision
- o Construction expenses
- o Contingency (5% of capital)

A factor of (331.3/307.3) was used to scale the 1985 dollar values to 1987 dollar values. (Statistics Canada. "Fixed Capital Flows and Stocks", Catalogue No. 13-568).

Capital costs for sequencing batch reactors (SBR's) and centrifuges were obtained from a May, 1986 Ontario Waste Management Corporation Report entitled: "Efficiency and Cost Assessment of Inplant Treatment Technologies". The capital costs for both treatment units were represented as 1986 Canadian dollar values and included the following:

- o Purchased equipment and installation
- o Instrumentation and controls
- o Piping
- o Electrical equipment and materials
- o Engineering and construction expenses

A factor of (331.3/314.3) was used to scale the 1986 dollar values to 1987 dollar values. (Statistics Canada. "Fixed Capital Flows and Stocks", Catalogue No. 13-568).

An example of a capital cost calculation is provided below:

Process	- Flow Equalization (see Figure 10)
Design Flow	- 5 ML/day (1.3 US MGD)
Total Capital	- $800,000 (1979 US$) as per Figure 10
Investment	- $800,000 x 1.1715 x (331.3/210.3)
	= $1,476,000
	(1987 CDN$)

1.3 Industrial Pre-Treatment Operating and Maintenance Costs

The 1980 EPA document entitled: "Treatability Manual - Volume IV, Cost Estimates" was used to obtain operating and maintenance costs for the following treatment processes:

- o Screening
- o Equalization
- o Neutralization
- o Primary clarification with ferric chloride addition
- o Final sedimentation with ferric chloride addition
- o Aerobic sludge digestion
- o Dissolved air flotation
- o Land application of sludges and sludge cake

The operating and maintenance costs from the EPA Treatability Manual were represented as 1979 US dollar values with the following cost component breakdown:

- o Labour (L)
- o Materials (M)
- o Chemicals (C)
- o Power (P)
- o Fuel (F)
- o Total Direct Operating Cost (TDC) = (L + M + C + P + F)
- o Plant overhead (60%L)
- o General and administrative expenses (40%L)

Annual operating and maintenance cost = (TDC + L)

For each treatment process, and a given flow, the annual operating cost was calculated using the Total Direct Operating Cost (TDC) and Labour cost (L) obtained from cost curves provided in the Treatability Manual.

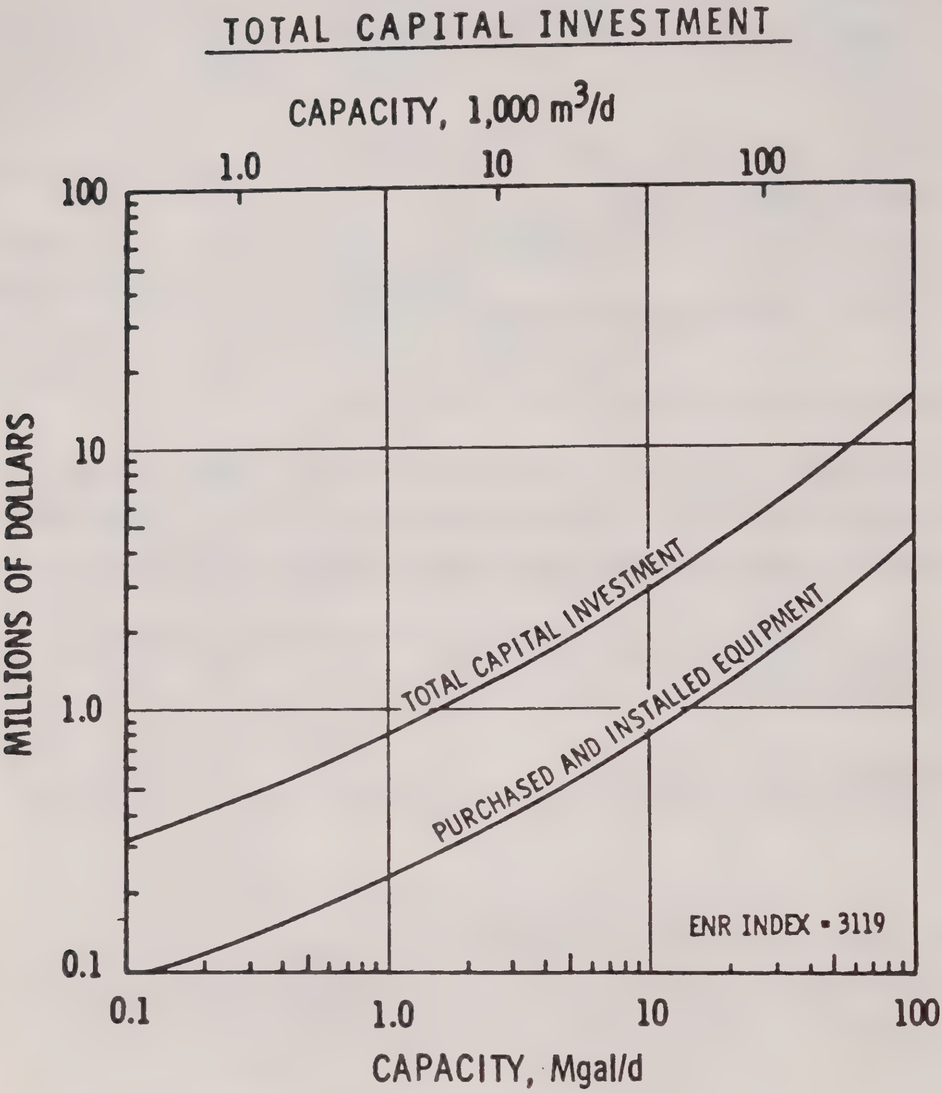
The following conversion rates were used to calculate equivalent 1987 Canadian dollar costs:

1. 1979 US$ x 1.1715 = 1979 Can$
Ref: 1979 U.S./Canadian exchange rate, noon average from "Bank of Canada Review)

2. 1979 Can$ x (172,9/100.0) = 1987 Can$
Ref: Unit lobar cost price index for government services from Statistics Canada, "Quarterly Economic Summary - Statistical Supplement", Catalogue No. 13-007E

Annual operating and maintenance costs for anaerobic reactors were obtained from a December, 1985 Agriculture Canada document entitled: "Final Report on the Evaluation of Single and Two Stage Anaerobic

Figure 10
COST CURVE FOR TOTAL CAPITAL INVESTMENT -
FLOW EQUALIZATION



Ref: EPA Treatability Manual, Volume IV - Cost Estimates, (1980)

Digestion of Poultry Manure". The operating and maintenance costs were represented as 1985 Canadian dollar values and included the following cost components:

- o Labour
- o Repair and maintenance costs (2 percent of major capital costs)
- o Insurance
- o Power
- o Miscellaneous supplies

A factor of (134.1/128.6) was used to scale the 1985 dollar values to 1987 dollar values. (Manufacturing unit labor cost index from Statistics Canada, "Quarterly Economic Summary - Statistical Supplement", Catalogue No. 13-007E).

Annual operating and maintenance costs for sequencing batch reactors (SBR's) and centrifuges were obtained from a May 1986 Ontario Waste Management Corporation Report entitled: "Efficiency and Cost Assessment of Inplant Treatment Technologies". The operating and maintenance costs for both treatment units were represented as 1986 Canadian dollar values and included the following cost components:

- o Labour
- o Maintenance
- o Power
- o Chemicals

A conversion rate of (134.1/133.2) was used to scale the 1986 dollar values to 1987 dollar values. (Manufacturing unit labor cost index from Statistics Canada "Quarterly Economic Summary - Statistical Supplement", Catalogue No. 13-007E).

An example of an operating and maintenance cost calculation is provided below:

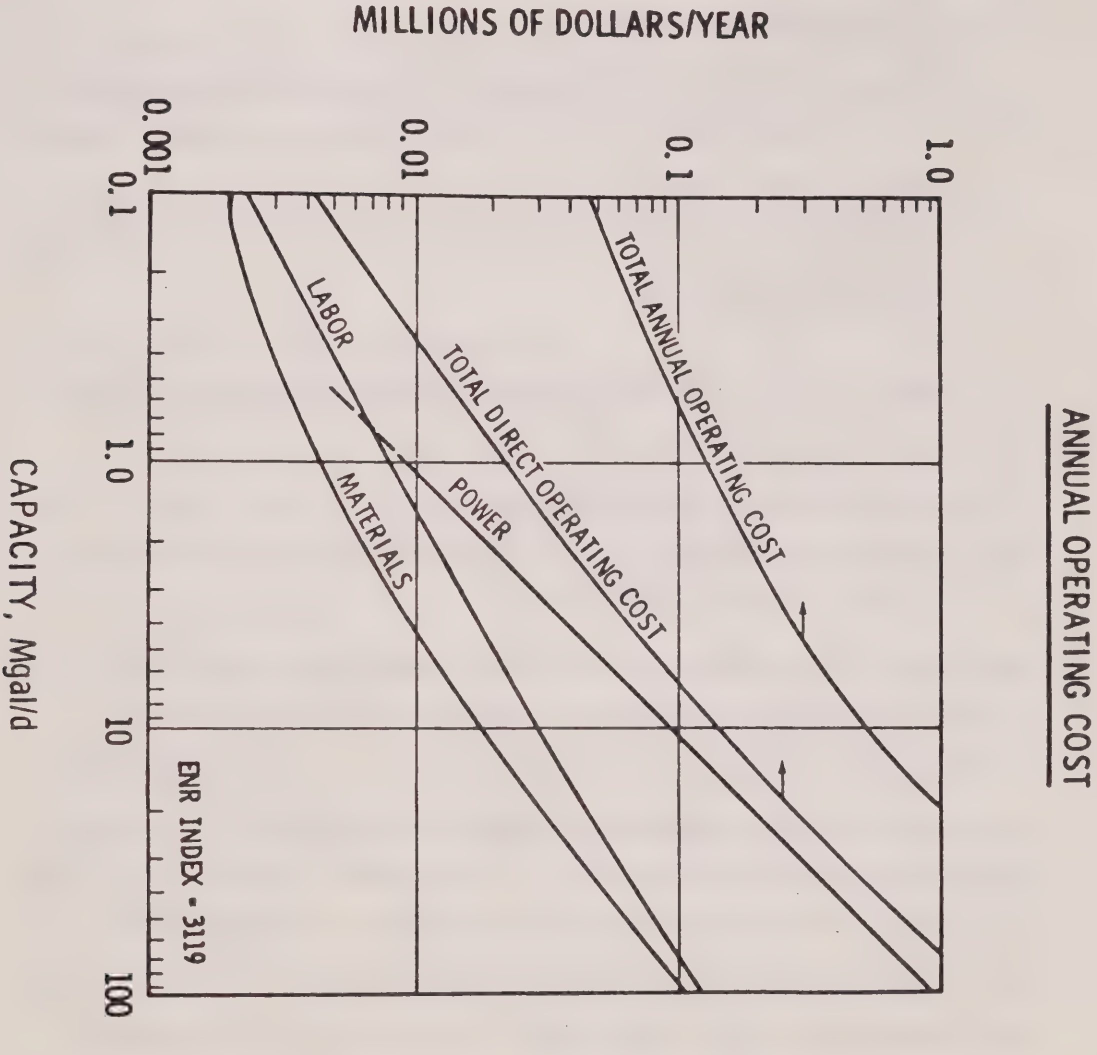
Process	- Flow Equalization (see Figure 11)
Design Flow	- 5 ML/day (1.3 US MGD)
Total Direct Annual Operating Cost	- $ 27,000 (1979 US$)
Labour Cost	$ 9,000 (1979 US$)
	- $ 36,000 (1979 US$) as per Figure 11
	- $ 36,000 x 1.1715 x (172.9/100.0) = $72,000 (1987 CDN$)

2.0 MUNICIPAL TREATMENT PLANT COSTS

Capital costs for municipal treatment plants were obtained from an October, 1986 Environment Canada document entitled: "Retrofitting Municipal Wastewater Treatment Plants for Enhanced Biological Phosphorus Removal," Report No. EPS 3/UP13. The costs were based on new facility costs for a conventional activated sludge plant employing chemical addition for the removal of phosphorus, with an effluent total phosphorus limit of 1.0 mg/L.

The costs in the Environment Canada report were developed using CAPDET (Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems), a model developed by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency. These costs are reliable when making relative comparisons between treatment system alternatives; however, experience has shown that as absolute estimates, the costs underestimate the costs of construction by approximately 25 percent. Therefore, all costs taken from the Environment Canada report were increased by 25 percent to account for this underestimation.

Figure 11
COST CURVES FOR ANNUAL OPERATING COST -
FLOW EQUALIZATION



Ref: EPA Treatability Manual, Volume IV - Cost Estimates, (1980)

The inflation factor used to scale the costs to 1987 Canadian dollar values was 331.3/266.6 (Statistics Canada "Fixed Capital Flows and Stocks," Catalogue No. 13-568).

Municipal WPCP facilities are designed on the basis of the following:

Design Average Flowrate
Design Peak Flowrate
Design BOD Concentration
Design SS Concentration

The design of various unit processes depending on the type of WPCP (i.e. primary, extended aeration, conventional activated sludge, lagoon) is dependent on one or more of the above variables. In general even for conventional activated sludge facilities the total capital cost is not very sensitive to influent BOD or SS concentrations over the range of values typical for such facilities.

Similarly it can be shown that total WPCP operating costs are only slightly sensitive to variations in influent wastewater BOD and SS concentrations.

The cost of treating high strength industrial wastewaters at a municipal WPCP is the incremental treatment cost of the excess loading. This argues for a surcharge formula based upon the marginal cost of treating the excess loading. As was discussed above, the impact of variations in design loading upon capital and operating costs are small. In effect the cost versus loading curve would tend to be horizontal and the marginal cost approaches zero. Accordingly, for purposes of cost analysis, only average removal costs ($/kg of contaminant removed) have been developed for BOD, SS and total P for three flowrates.

3.0 FINAL COST ESTIMATES

Estimated total costs for industrial pre-treatment are provided in Table D.2 while municipal costs for BOD and SS are provided in Table D.3. Municipal costs for phosphorus removal are provided in Table D.4.

The following assumptions were used in calculating the average annual costs:

- Interest rate used for amortization 6%
- Annualized capital cost calculated using formula
- $A = (Pi(1+i)^n)/(1+i)^n-1)$

Where:
A = the annualized value
P = the present value
i = the interest rate
n = the amortization period

- Amortization period was 20 years with interest compounded yearly
- to calculate average cost per kg of contaminant removed, we assumed to following removal levels for municipal treatment:

BOD - 200 mg/L
SS - 200 mg/L
Phosphorus - 5 mg/L

- Total annual costs = O + M costs + annualized capital costs
- Average cost per KG BOD or SS removed
  = Total Cost / (total KG BOD or SS removed)

TABLE D.2

COST ANALYSES FOR INDUSTRIAL PRETREATMENT OPTIONS

Waste Strength		Volume	Target	Target	Total Cap.	Annual	Annualized	Total	Cost/kg BOD or SS Removed		
BOD mg/L	SS mg/L	ML/d	Rem. BOD (%)	Rem. SS (%)	Costs ($)	O & M Costs ($)	Cap. Cost 20 Years	Annual Costs ($)	O&M	Annualized Capital	Total
10,000	500	0.05	90		1,398,600	362,280	121,940	484,210	2.21	0.74	2.95
10,000	500	0.5	90		3,542,000	1,100,670	308,810	1,409,480	0.67	0.19	0.86
10,000	500	5	90		12,384,000	3,205,850	1,079,690	4,285,540	0.20	0.07	0.26
5,000	500	0.05	90		1,236,500	335,630	107,800	443,440	4.09	1.31	5.40
5,000	500	0.5	90		2,931,000	836,410	255,540	1,091,940	1.02	0.31	1.33
5,000	500	5	90		9,318,000	2,992,080	812,390	3,804,470	0.36	0.10	0.46
500	500	0.05	90		590,320	211,840	51,470	263,300	25.79	6.27	32.06
500	500	0.05	60		1,076,000	246,430	93,810	340,240	45.01	17.13	62.14
500	500	0.5	90		2,279,000	904,810	198,690	1,003,500	9.80	2.42	12.22
500	500	0.5	50		1,869,000	770,100	162,950	933,040	16.88	3.57	20.45
500	500	5	50		6,141,000	3,907,190	535,400	4,442,590	8.56	1.17	9.74
500	500	5	90		670,800	3,942,640	584,830	4,527,470	4.80	0.71	5.51
500	5,000	0.05		90	622,000	253,540	54,230	307,770	3.09	0.66	3.75
500	5,000	0.5		90	1,120,000	743,350	97,650	841,000	0.91	1.12	1.02
500	5,000	5		90	6,286,000	3,705,960	548,040	4,254,000	0.45	0.07	0.52
5,000	5,000	0.05		90	982,000	266,040	85,610	351,650	3.24	1.04	4.28
5,000	5,000	0.5		90	2,450,000	791,940	213,600	1,005,540	0.96	0.26	1.22
5,000	5,000	5		90	7,668,000	3,989,290	668,530	4,657,830	0.49	0.08	0.57

NOTE: all dollars are 1987 $ Canadian

TABLE D.3

COST ANALYSES FOR MUNICIPAL
TREATMENT OF BOD AND SS IN SEWAGE

Plant Capacity (ML/d)	4.50	13.60	36.40
Total Capital Cost	$4,516,900	$7,790,500	$13,770,600
O and M/year	$ 404,100	$ 910,000	$ 1,948,100
Annualized Capital Cost	$ 393,800	$ 679,200	$ 1,200,600
Total Annual Costs	$ 797,900	$1,589,300	$ 3,148,700
Average Costs/L			
O and M	$ 0.246	$ 0.183	$ 0.147
Annualized Capital	$ 0.240	$ 0.137	$ 0.090
Total Annual	$ 0.486	$ 0.320	$ 0.237
Average Costs/KG BOD Removed			
O and M	$ 1.23	$ 0.92	$ 0.73
Annualized Capital	$ 1.20	$ 0.68	$ 0.45
Total Annual	$ 2.43	$ 1.60	$ 1.18
Average Costs/KG SS Removed			
O and M	$ 1.23	$ 0.92	$ 0.73
Annualized Capital	$ 1.20	$ 0.68	$ 0.45
Total Annual	$ 2.43	$ 1.60	$ 1.18

NOTE: all dollars are 1987 $ Canadian

TABLE D.4

COST ANALYSES FOR CHEMICAL
PHOSPHORUS REMOVAL AT MUNICIPAL TREATMENT PLANTS

Capacity (ML/d)	Capital Cost	O & M Cost	Annualized Capital (20 yr, 10%)	Total Annual Cost	$/kg TP Removed
4.5	$201,300	$ 58,100	$23,600	$ 81,700	$9.95
13.6	$211,600	$161,400	$24,900	$186,200	$7.50
36.4	$247,900	$189,600	$29,100	$218,700	$3.29

NOTE: all dollars are 1987 $ Canadian

APPENDIX E

STATISTICAL ANALYSIS

1.0 INTRODUCTION

This appendix documents the statistical analyses undertaken as part of the data analysis tasks for this study. Summary statistics are shown in the main report and in other appendices, while specific test are considered here.

1.1 Confidence Intervals

Confidence intervals for proportions are estimated using the following formula (Crow, Davis and Maxfield, 1960):

$$[n + (z^2/2) \pm ((n + z^2/2)^2 - (N + z^2)n^2/N)^{0.5}] \, (N + z^2)^{-1}$$

where N = sample size

n = sub-sample size

z = normal deviate corresponding to the 2-tail test probability level (e.g. Z(P = .95) = 1.96)

For total respondents with an ESSS program, we have

$n = 33$

$N = 192$

$n/N = 0.171$

Ninety-five percent confidence intervals on n/N are:

$$[33 + (1.96^2/2) \pm ((33 + 1.96^2/2)^2 - (192 + 1.96^2)\, 33^2/192)^{0.5}] \times (192 + 1.96^2)^{-1} = (0.125, 0.232)$$

1.2 Industrial Pre-Treatment Cost Curves

Data in Table D.2 of Appendix D were analyzed using regression analysis in order to derive cost curve relationships. Initially, both linear and log-linear forms were tested, these two forms being respectively:

$$Y = a + bx$$

and

$$\ln(Y) = c + d\ln(x)$$

The latter converts to the exponential equation:

$$Y = C\,x^d \qquad \text{where } C = e^c$$

The log-linear form had superior test statistics and was adopted for subsequent analysis.

As a starting point, total annualized capital costs and total annual operating and maintenance costs were regressed against the following independent variables:

- influent BOD concentration
- influent SS concentration
- influent flow volume
- BOD removal efficiency

Positive coefficients were expected for each of these variables; however, coefficients were negative for SS and removal efficiency. These were therefore both dropped.

Final regression equations used for subsequent cost estimation purposes in the main report are:

$$O \& M \text{ cost} = 1.33\ BOD^{0.0515}\ Q^{0.551},\ R^2 = 0.977, \text{ sample size} = 15$$

$$\text{Capital cost} = 2.97\ BOD^{0.229}\ Q^{0.478},\ R^2 = 0.963, \text{ sample size} = 15$$

where operating and maintenance and capital costs are measured in million of 1987 dollars and:

$$BOD = (mg/l)/1000$$
$$Q = 10^6 L/d$$

Both these curves represent costs for technologies achieving a 90% removal efficiency for BOD.

1.3 Municipal Sewage Treatment Cost Curves

Municipal sewage treatment cost data are provided in Table D.3 of Appendix D. Only cost and flow data are provided as variables in this table. Regression of total cost data against flow yielded the following results:

$$OM \text{ cost} = 129{,}554\ Q^{.7521},\ R^2 = .908$$
$$\text{Capital Cost} = 1{,}999{,}885\ Q^{.5324},\ R^2 = .998$$

Where OM and capital cost are measured in 1987 dollars and flow (Q) is measured as 10^6L/d. These curves were used to extrapolate municipal cost data.

1.5 Impact of ESSS Programs on Industrial Compliance

Analysis of the national ESSS municipal survey data base was undertaken to examine interrelationships between municipal sewer use control programs and industrial compliance indicators. The analysis was conducted using regression techniques to verify the validity of the following general model:

Industrial Compliance = f (enforcement activity and charges, other explanatory variables)

Specific variables used in this model are described in Table E.1. The hypothesis of this model is simply that compliance rates will improve as enforcement activity increases and when user charges penalize noncompliance while other variables such as the level of industrial activity or the nature of treatment systems will also influence both compliance levels and the nature of regulatory programs.

The full set of survey data covered 192 respondents however not all respondents answered every question. After editing of the data set to eliminate respondents with incomplete responses, 35 respondents remained. This edited data set was used for regression analyses.

A preliminary investigation of the data set was conducted using ordinary least-squares (OLS) regression techniques. Sample results are provided in Table 2.

Generally, correlation coefficients are low but the relationships have statistically significant F-statistics. Most of the independent variables do not have significant coefficients and certain of the variables have signs that are unexpected. POP (population) has a negative coefficient in the first two tests, though a positive relationship was expected to the

TABLE E.1

DESCRIPTION OF REGRESSION VARIABLES

LABEL	DESCRIPTION	TYPE OF DATA	SURVEY DATA SOURCE QUESTION
INDUSTRIAL COMPLIANCE INDICATORS			
VIOL	No. of bylaw violators	integer >0	Q19
VIOLE	VIO/# monitored establishments	0.0 to 1.0	Q19/Q18
PBLM	Industrial Problem Score	0.0 to 1.0	Q11 (summary index)
PBLME	PBLM/# monitored establishments	0.0 to <1.0	PBLM/Q18
INDICATORS OF ENFORCEMENT ACTIVITY AND CHARGES			
INSP	Use of plant inspections	(0,1)	Q15-pt 2
#BOD	No. of BOD samples to trigger enforcement	0,1,2,...	Q16(b)-BOD
NEG	Use of negotiations with volators	(0,1)	Q17-pt 1
PROS	Use of prosecution and fines	(0,1)	Q17-pt 2
#ESTA	No. of establishments sampled	0,1,2,...	Q18
AGREE	Negotiated agreements to exceed BOD/SS limits	(0,1)	Q23-pt 2,3
FFEE	User charge - flat fee	(0,1)	Q24-pt 2,3,6
NFEE	negotiated fee	(0,1)	Q24-pt 4
QFEE	flow-based fee	(0,1)	Q24-pt 5, 7
ESSS	quality-based fee	(0,1)	Q24-pt 8
#SAMP	No. of samples/establishment	0,1,2,...	Q16(a)/Q18
PGM1	Basic regulation program (INSP + NEG + AGREE + QFEE)	0,1,2,3,4	see above
PGM2	Enhanced regulation program (PROS + ESSS)	0,1,2	see above
OTHER VARIABLES			
POP	municipal serviced population	0,1,2,3,...	Q7
IND	% industrial effluent in total effluent	0 to 100	Q9-pt 3
LAG	% flow treated in lagoons	0 to 100	Q10(b)
PRIM	% flow treated in primary systems with or without P-removal	0 to 100	Q10(b)
SEC	% flow treated in secondary or tertiary systems with or without P-removal	0 to 100	Q10(b)
CAP	treatment plant capacity utilization (ave. flow/design flow)	>0.0	Q10(c)

TABLE E.2

PRELIMINARY ORDINARY LEAST SQUARES REGRESSION RESULTS

INDEPENDENT VARIABLES	DEPENDENT VARIABLES			
	PBLME	VIOLE	VIOL	ESSS
POP	-0.015*	-0.00050	0.024*	0.0021*
IND	0.034	0.0099*	0.22*	0.0047
LAG	-0.0063	0.0015	- - -	- - -
CAP	-0.11	0.24	- - -	- - -
INSP	-2.38*	-0.064	- - -	- - -
#BOD	-0.13	0.0077	- - -	- - -
PROS	1.56	0.14	- - -	- - -
#ESTA	- - -	- - -	0.0093*	- - -
AGREE	-1.56	0.21	- - -	- - -
FFEE	-1.57	0.012	- - -	- - -
ESSS	2.71	-0.14	- - -	- - -
#SAMP	0.026*	0.0027*	- - -	- - -
VIOLE	-5.93*	- - -	- - -	- - -
PBLM	- - -	- - -	- - -	0.032*
Intercept	4.58	-0.29	-4.04	-0.29
R^2	.58	.57	.58	.50
R^2-adj.	.35	.36	.53	.45
F-score	2.54*	2.75*	13.99*	10.28*
n	35	35	35	35
k	12	11	3	3

* significant at P=0.05

extent that industrial activity and the likelihood of associated discharge problems correlates with population. A positive sign on #SAMP may contradict expectations if it is assumed that noncompliance would fall with increased sampling. Conversely, the likelihood of detecting violators would be expected to increase as more samples are collected.

An underlying difficulty that may bias OLS results is the interdependency of variables. In effect, control program initiatives such as inspection, prosecution and ESSS charges may be a municipal reaction to noncompliance. The regression explaining ESSS (Table 2) suggests that this is in fact the case. Statistically, this implies that the regulation and charge variables are also endogamous and thus, stochastic in nature. Under such circumstances, two stage least squares (TSLS) regression is used to provide unbiased estimators of coefficients.

TSLS results are provided in Table 3. Policy variables are aggregated into two new variables PGM1 and PGM2 as described in Table 1. PGM1 measures the use of more frequently encountered and less stringent control mechanisms while PGM2 measures the use of more stringent mechanisms namely prosecutions and ESSS programs. The OLS regression for VIOL including PGM2 has a negative coefficient on this variable while with the TSLS regression, the PGM2 coefficient becomes negative as expected. In neither case is the coefficient significant.

TABLE E.3

TWO-STAGE LEAST SQUARES REGRESSION RESULTS

INDEPENDENT VARIABLE	DEPENDENT VARIABLE PGM2	VIOL	VIOL	VIOL
POP	0.0031*	0.024*	0.026	0.017
IND	0.017*	0.22*	0.23	0.18
#SAMP	- - -	0.0093*	0.0094*	0.0099*
PBLM	0.058*	- - -	- - -	- - -
PGM1	0.086	- - -	- - -	- - -
PGM2	- - -	- - -	-0.57	1.91
Intercept	-0.74*	-4.037	-4.073	-3.88
R^2	.59	.58	.44	.59
R^2-adj.	.53	.53	.37	.54
F-score	10.58*	13.99*	5.89*	10.89*
no. ols.	35	35	35	35
no. vars.	4	3	4	4
Regression Type	OLS	OLS	TSLS	OLS

* significant at P=0.05

APPENDIX F

PROFILE OF MUNICIPALITIES REPORTING THE USE OF AN EXTRA-STRENGTH SEWER SURCHARGE PROGRAM

PROFILE OF MUNICIPALITIES REPORTING THE USE OF

AN EXTRA-STRENGTH SEWER SURCHARGE PROGRAM[1]

	SERVICE POPULATION (1000's)	TYPE[2] OF TREATMENT	INDUSTRIAL[3] ACCOUNTS (no.)	ESSS START DATE	FIRMS COVERED BY ESSS MONITORED (no.)	FIRMS COVERED BY ESSS CHARGED (no.)	GENERAL[4] RATE FORMULA	UNIT RATES (1987) BOD (c/kg)	UNIT RATES (1987) SS (c/kg)	OTHER ESSS PARAMETERS	COMMENTS
Summerville, PEI	15	P	130 (c)	n.av.	0	0	A	- -	442	grease	program not used yet
Sussex, NB	4	L	40	n.av.	n.av.	n.av.	A	10.3	- -	- - -	- - -
Granby, PQ	39	S	n.av.	1985	12	12	n.av.	n.av.	- -	COD	- - -
Kingston, ON	67	P	n.av.	1969	3	1	C	see comment		volume	BOD+SS charge tied to property tax
R.M. Durham, ON	276	S	3843 (c)	1974	1	1	B	15	15	- - -	rates vary across WPCP's
R.M. Metropolitan Toronto, ON	2073	S	n.ap.	1967	84	84	B,M	23.3	23.3	grease, phenol	- - -
R.M. Peel, ON	500	S	n.av.	1975	35	28	A,M	41.8	34.9	grease	- - -
R.M. Halton, ON	264	S	3809 (c)	1979	4	4	A	n.av.	n.av.	- - -	- - -
R.M. Hamilton-Wentworth, ON	428	S	2000	1972	7	7	A	23.1	19.8	pH, NH_4 cyanide	2 formulas in use
R.M. Niagara, ON	312	S	n.ap.	1976	20	18	B,M	23.2	23.2	- - -	- - -
Brantford, ON	75	S	1500 (c)	1977	13	13	B	n.av.	n.av.	COD	- - -
R.M. Waterloo, ON	323	S	n.ap.	1973	33	33	A	14.6	12.6	phenol	- - -
Chatham, ON	42	S	230 (c)	1964	2	2	B	44.0	- -	- - -	- - -
Windsor, ON	204	P	n.av.	1974	28	25	B,M	30.5/50.4	30.5/50.4	grease	rates vary across WPCP's
London, ON	266	S	n.av.	1961	17	15	A	18.3	15.7	- - -	- - -
Walkerton, ON	5	S	8	1972	4	1	n.ap.	n.ap.	- -	- - -	cost sharing agreement
Hanover, ON	5	S	10	1981	1	1	n.ap.	n.ap.	n.ap.	- - -	cost sharing agreement
Strathroy, ON	8	L	n.av.	1953	5	1	A	26.7	22.9	PO_4	- - -
Brandon, MB	39	L	n.av.	1973	3	3	A	4.1	- -	- - -	proposed formula includes BOD, SS, TKN, grease and C1 demand
Portage La Prairie, MB	13	S	n.av.	1982	3	3	A	41.8	31.5	- - -	- - -

PROFILE OF MUNICIPALITIES REPORTING THE USE OF

AN EXTRA-STRENGTH SEWER SURCHARGE PROGRAM[1] - cont'd

	SERVICE POPULATION (1000's)	TYPE[2] OF TREATMENT	INDUSTRIAL[3] ACCOUNTS (no.)	ESSS START DATE	FIRMS COVERED BY ESSS		GENERAL[4] RATE FORMULA	UNIT RATES (1987)		OTHER ESSS PARAMETERS	COMMENTS
					MONITORED (no.)	CHARGED (no.)		BOD (c/kg)	SS (c/kg)		
Winnipeg, MB	600	S	8000 (c)	1958	68	60	A	26.0	19.0	- - -	- - -
Regina, SK	170	S	3500 (c)	1976	7	6	B	11.0	11.0	grease, PO_4	- - -
Swift Current, SK	16	S	50	1974	1	0	C	4.2	1.1	grease	rates set in 1974, but not used (also, see Brooks, AL)
Yorkton, SK	16	S	50	1980	0	0	A	72.9	57.9	- - -	- - -
Saskatoon, SK	182	P	4570 (c)	1970	12	12	A	3.2	5.5	grease	- - -
Prince Albert, SK	35	P	200	1987	0	0	B	- -	n.av.	- - -	block rate structure used
Medicine Hat, AL	45	S	40	n.av.	0	0	A	16.1	16.1	grease	proposed program
Brooks, AL	9	L	338 (c)	1973	0	0	C	59.4	47.5	- - -	charge applies only when limits for BOD or SS exceeded
Cochrane, AL	4	P	6	1983	0	0	B	22.0	33.0	grease	no violators on system
Innisfail, AL	6	S	32	1978	0	0	B	8.8	11.0	grease	- - -
Red Deer, AL	55	S	n.av.	1971	5	5	C	18.3	20.0	grease	see Brooks, AL
Creston, BC	4	S	3	1977	1	1	n.ap.	n.ap.	- -	COD, pH	cost sharing agreement
Dist. of Matsqui, BC	50	P	n.av.	1986	10	10	n.av.	n.av.	n.av.	- - -	- - -
Prince George, BC	68	S	1355 (c)	1975	1	1	B	77.0	54.0	grease	- - -

NOTES:

1 n.ap. - not applicable; n.av. - not available

2 Principal type of treatment system indicated as: L - lagoon, P - primary, S - secondary, T - tertiary

3 Industrial Accounts were not always identified separate; "c" denotes "includes commercial accounts."

4 Rate Formulas: A - flow x [(conc'n - allowable conc'n)/allowable conc.] x rate per unit load

B - flow x [(conc'n - allowable conc'n) x rate per unit load

C - flow x conc'n x rate per unit load

M - formula A or B but based on the maximum exceedance of listed parameters